Spring 2019

The Impact of Jigsaw Learning on Student Engagement in Beginning Students at a Community College: An Action Research Study

Kalina White

The Impact of Jigsaw Learning on Student Engagement in Beginning Students at a Community College: An Action Research Study

by

Kalina White

Bachelor of Arts
Earlham College, 2000

Master of Science
University of Connecticut, 2002

Submitted in Partial Fulfillment of the Requirements

For the Degree of Doctor of Education in

Curriculum and Instruction

College of Education

University of South Carolina

2019

Accepted by:

Peter Duffy, Major Professor

Cathy Brant, Committee Member

Linda Silvernail, Committee Member

Suha Tamim, Committee Member

Cheryl L. Addy, Vice Provost and Dean of the Graduate School

Dedication

To my husband, Brandon, and my daughter, Kiralise.

Acknowledgments

Completion of this dissertation and degree would not have been possible without the support and help from so many family and friends.

To my family, who supported me the whole way, especially Karen who had Been There, Done That, and Sidra, who was totally wrong about the hegemony but it was a good idea while it lasted. And to Brandon and Kiralise, who kept me in paper, ink, and time.

To my cohort at USC – this whole thing was much more fun with you. Thank you for the perspective.

To the entire team at NCC – thank you for your support and patience, especially when my focus was split during critical times.

To my advisor, Peter Duffy, and my committee of Dr. Linda Silvernail, Dr. Suha Tamim, and Dr. Cathy Brant – thank you for reading this thing and for the feedback that helped me improve.

To my students, thank you for your candor and support as you told me about all the things that would help you learn.

Abstract

The purpose of this action research study is to explore the impact of the cooperative learning technique of the jigsaw method on student engagement in the beginning biology laboratory at Northern Community College (NCC). Professorial observations, a student survey, and interviews were used to investigate whether or not jigsaw methods should be adopted at NCC which serves a moderately large metropolitan area in the Northern United States. Data were collected over a 6-week period over the Fall 2018 semester. Over three weeks, one of three sections were exposed to a jigsaw version of the normal laboratory protocol while the other two sections used a laboratory protocol in use at this school for several years. After each laboratory session, students were asked to complete a survey indicating their perceived value of the activity and their degree of effort related to the cognitive and affective domains of student engagement. This survey constituted the primary data set and triangulated by the professor-researcher's observations of student behaviors and short semi-structured interviews striving to elucidate deeper understanding of student perceptions and self-perceived engagement. The guiding research question of this action research (AR) project was to ask, "How does the use of the jigsaw method in the beginning biology laboratory impact student engagement?" Findings were shared with student-participants in three focus groups that lasted approximately an hour, located extrinsic of scheduled laboratory time but in the laboratory room. These focus groups enabled the professor-researcher and

student-participants to reflect on the findings from the biology laboratory and to engage student-participant voices in the creation of an action plan for future laboratory activities.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

AR……………………...……………………………………………Action Research

ASPECT……..……………..Assessing Student Perspective of Engagement in Class Tool

ATD…………………………………………………………..……Achieving the Dream

CCSSE………………………………Community College Survey of Student Engagement

DiP……………………………………………………………Dissertation in Practice

ML…………………………………………………….Moderately Large, as in ML city

NCC…………………………………………………...Northern Community College

PoP…………………………………………………………….Problem of Practice

RQ……………………………………………………………Research Question

Chapter 1 Introduction

Introduction

It was an average day in the beginning biology laboratory at Northern Community College (NCC) located in Moderately Large City (ML City). Kurt, who works as a paramedic when not attending classes, excitedly described the relationship between cardiac function and pulmonary output in some detail to his enraptured classmates as they measured their own carbon dioxide output. At another table, Leila and Tommie used what they knew from class and their own lives to hold a fast-paced discussion about how long they needed to wait after eating cookies before checking their pulse. At a third table, Celeste was describing patterns from her experimental results, but neither she nor her partners were able to draw any conclusions. Bored, they started texting on cell phones.

Beginning biology is a critical course for students at NCC and for the region at large. Beginning biology, a for-credit course, is taken by approximately half of all students who attend NCC and usually in their first semester. In any given year, NCC serves approximately 26,000 for-credit students. To date, NCC is responsible for having contributed to the education and personal development of 1 in 3 adults in the county through credit and noncredit courses. Ultimately, beginning biology is one of the largest classes at NCC, but it has a success rate (earning an A, B, or C) of only 62%.

Beginning biology is meant for students who might never have set foot in a biology laboratory. I have taught students aged 15 to 72 in this course, students who dropped out of high school after their favorite teacher was shot and killed in front of them, illiterate students, students who already have their doctorate degrees, and in one memorable case, a man who claimed to be a king from a far-away country. There is no typical student in this course except that all students have goals no matter how fuzzy. This course is a step on the path to their dreams, yet all too often becomes a derail. One third of the students enrolled in this course will complete with a *D*, an *F*, or a *W*. They will either have to repeat the course or change their dreams. A quarter of the students do not return for more classes in the spring.

In addition to the low success rate, there are demographic patterns in who succeeds in beginning biology at NCC. While women and men are equally likely to succeed (64% and 62%) and 69% of white students succeed, only 47% of black students do. Fall to spring retention, the re-enrollment of a fall student the following semester, is 77% for white students (male or female) and black male students but only 67% for black female students.

There is no clear understanding at NCC as to why success rates vary. Research indicates that student engagement (defined as a three part model of behavior, cognitive effort, and emotional feelings for this Dissertation in Practice (DiP) (Fredricks, Blumenfeld, & Paris, 2004)) positively impacts student learning and outcomes (Chi & Wylie, 2014; Griffin & Howard, 2017; Handelsman, Briggs, Sullivan, & Towler, 2005; Hodges, 2018; Menekse, Stump, Krause, & Chi, 2013; Price & Tovar, 2014; Sinatra, Heddy, & Lombardi, 2015; Theobald, Eddy, Grunspan, Wiggins, & Crowe, 2017;

Wiggins et al., 2017). Peer reviewed literature suggests one potential way to improve student engagement to effect desired outcomes is to use the jigsaw method. This curricular technique invites students to become individual experts on specific tasks and then work collaboratively to successfully accomplish activities (Chi & Wylie, 2014; Griffin & Howard, 2017; Hodges, 2018; Theobald et al., 2017). The goal of this action research (AR) project seeks to understand if jigsaw methods elucidate greater student engagement than the existing laboratory activities and to formulate an action plan (AP) to improve the course for all students.

Description of the Setting

NCC consists of four campuses and five centers (which do not offer all classes leading to an associate's degree) spread across a large geographic area. It takes an hour to drive from one end of the area covered to the other and it is impossible to visit all nine sites in one day. Historically, NCC was made up of four individually accredited and operating colleges but a previous president somewhat united them. The goals and culture of the four campuses are not always aligned although classes taken at one place will count at the others.

The mission of NCC seeks to prepare students for success through affordable access to high quality higher education. Faculty, of whom I am one, take the mission seriously in beginning biology, constantly evaluating what our students need to know, how we present it, and how we assess it. Although we innovate frequently with an entire laboratory overhaul within the past five years and a current on-going overhaul of course learning outcomes, we wonder if we are providing a high-quality education when our success rate is so low.

This action research study investigated beginning biology at the most urban and largest of NCC's four campuses. Based on conversations with my coworkers and my personal experiences, I have observed or learned the following: this campus tends to have the most diverse students compared to the more suburban nature of the other three. Students at this campus tend to be the neediest, both in terms of remedial coursework but also in terms of housing, food security, and other life circumstances. This campus is the only one available by bus most years. Most students attending this campus attended the city high schools, which vary widely in their quality but generally are not as well-rated as the suburban high schools in this area which feed students to the more suburban campuses of this college.

There are approximately 160 programs from which an NCC student may choose, but most of the students at the most urban campus will choose to major in allied health or nursing or transfer to a four-year college. Beginning biology is a prerequisite for 22 programs but serves as a general distribution credit for about half the programs at NCC. It is one of the top ten most enrolled courses at NCC, along with other mainstays such as first year English and Introduction to Psychology.

Beginning biology consists of a lecture and a laboratory component. At the urban campus these two pieces may not be taught by the same professor. Most sections are taught by part-time faculty. At the time I write this dissertation, I am the only full-time faculty member at the urban campus who takes direct responsibility for the quality of this course.

The lecture component of this course is usually taught in a sage on the stage sort of way. Most of the opportunity for student interaction and experiential learning occurs in the laboratory, which occurs once a week for fifteen weeks. The laboratory manual at NC has fourteen sections, one for each week leading up to a cumulative written laboratory final. Nearly every section has a prelab, a postlab, a protocol (written directions on how to do the lab, a little like a recipe from a cookbook), and an associated study guide. There are also practice quizzes available through blackboard. NCC beginning biology protocols start with a very basic introduction to the scientific method, and over the course of the semester progress through atoms, chemistry, and cells. Students at the end of this course are prepared to take further courses in Majors Biology, Microbiology, and Anatomy and Physiology.

To complete each week's expected work, students must work together in groups of 2, 3, or 4 to complete the protocols. Students completing group work in the beginning biology laboratory at NCC are not usually given task assignments. Instead, students are left to self-assign tasks. Although students may choose to opt out of group work, they are generally accustomed to operating within these small groups.

This action research study seeks to determine how laboratory protocols modified to rely on principles of jigsaw methodology impact student engagement compared to the existing laboratory protocols.

Background of the Problem

The faculty at NCC have been making efforts for several years to improve the success rates of beginning biology. To date, there have been no significant improvements in success rates and student opinions about this matter have not been solicited. What follows is a history of recent efforts and understandings of beginning biology.

Students at NCC are often financially precarious and, in the attempt to better meet the material needs of students, several years ago the biology faculty created a laboratory manual just for the students at two of the campuses and one of the centers belonging to NCC. Although dozens of faculty may teach this beginning biology course, I am responsible for the maintenance and improvement of this laboratory manual with the review of my peers and co-faculty. Over 1000 students per year use this custom laboratory book which our biology department provides for free. We estimate that in the first five years, we saved our students over half a million dollars compared to the cost of the laboratory book we previously required. While students who complete the course are now better prepared to succeed in the next biology class, this laboratory book did not make an observable difference in success rates.

At NCC, a student might wind up needing to take developmental (remedial) courses in reading, English, or math before being considered prepared for college courses. Students who need the most developmental work in all three arenas are least likely to complete beginning biology and are considered the most developmental needy. In 2015, the biology division decided to place a prerequisite on the course that blocks students with the most developmental need students while allowing the students with only small developmental need. This affected approximately 12.8% of NCC students in any given year. Students who need only some developmental work currently succeed beginning biology approximately half the time according to internal NCC data.

The same internal data revealing that the most developmentally needy students are least likely to succeed also demonstrated that students who need no developmental work are second least likely to succeed. The biology division responded by creating a hybrid pathway for the four biology courses that lead to nursing and allied health. At NCC, hybrid refers to courses which are taught partially online and partially in person. The hybrid biology courses have normal laboratory periods and abbreviated lecture periods. Most lecture work is completed through online activities including videos and assignments. In class lecture work generally consists of activities related to the material or taking tests. Although early indications are that hybrid students are more likely to succeed than traditional students, constraints imposed by external accreditors prevent an enrollment increase of this program. Furthermore, students needing some developmental work are less likely to succeed in a hybrid course compared to a traditional course.

As of 2018, the success rate (defined as earning a C or better at NCC) of this course across all modalities, campuses, and students stands at 62% with differences by race and by race and gender. The previous efforts to improve this laboratory curriculum have not significantly impacted student outcomes to date.

NCC is an Achieving the Dream (ATD) college that participates in periodic evaluation of student engagement via the Community College Student Survey of Engagement (CCSSE). The CCSSE is an instrument that community colleges across the United States use to benchmark to peer institutions, evaluate institutional effectiveness, and identify areas for improvement ("CCSSE - About CCSSE," n.d.). One component of the CCSSE addresses institutional student engagement as described by active and collaborative learning. At a score of 45.2% with 75% of students responding in 2016, NCC scores below the average for Extremely Large Community Colleges (49.5%) as well as below the average for ATD colleges (50.4%). There is room for improvement in NCC's use of active and collaborative learning.

Goal of the Study

The professor-researcher of the present action research study seeks to understand if using jigsaw methods in the beginning biology laboratory impacts student engagement when students are already accustomed to working in groups.

What follows is a brief background of the study, the identified problem of practice (POP), research question (RQ) and purpose of the study (PS). A brief review of the relevant literature and the action research used to collect, analyze and report data is also included, as well as the findings of the present study. This Chapter One concludes with an overview of each chapter of this Dissertation in Practice (DiP).

Background of the Study

Student engagement is a construct with no consensus in the peer reviewed literature (Fredricks & McColskey, 2012). Although all definitions of engagement are multivariate, the given number of variables ranges. In this DiP, as NCC requested I not include grades as a data point in order to protect students, only the three components consisting of behavior (how students demonstrate participation in the activities), emotion/affective (how they feel about the activities and the class as a whole), and cognitive effort (how hard they work cognitively to learn the material) will be considered (Fredricks et al., 2004) through observations, student comments, and a modified Assessing Student Perspective of Engagement in Class Tool (ASPECT) survey as described in Chapter Three. Furthermore, there is agreement that student engagement positively correlates with student outcomes including GPA, grades, retention, and in some cases, graduation as described by Price and Tovar (2014).

Student engagement, no matter how nebulously designed, becomes therefore a desirable component of higher education. Price and Tovar (2014) describe engagement as consisting both of the internal student state as well as the extrinsic environment of said student. The extrinsic environment is most often measured at the institutional level through nationally normed assessments such as the CCSSE. While the CCSSE holds some information for individual educational-practitioners, there is a gap between the institutional environment and the choice of classroom activities. To this end, Chi and Wylie (2014) developed the ICAP framework in the attempt to link active learning and cognitive engagement. ICAP predicts that as students move through a hierarchical taxonomy of cognitive engagement, their learning will increase and provided supportive data (Chi et al., 2018; Chi & Wylie, 2014). The argument that interactive activities improve student learning best, followed by constructive, active, and passive learning were also supported by Menekse, Stump, Krause, and Chi (2013) and Theobald, Eddy, Grunspan, Wiggins, and Crowe (2017).

Specific active or collaborative learning activities found to link positively to student engagement include the jigsaw method (Chi & Wylie, 2014; Griffin & Howard, 2017; Theobald et al., 2017; Wiggins, Eddy, Grunspan, & Crowe, 2017). In the jigsaw method, each member of a group becomes an expert in a subtask and is responsible for teaching or leading the group in that area. Only when all group members work interactively and constructively together can the task be completed (Theobald et al., 2017).

Once implemented, the reflective educator will need some way to determine whether the technique improved student engagement. Wiggins et al. (2017) addressed this through the creation of the ASPECT survey for higher educational professionals seeking to quantify the impact of active learning activities in their classrooms and laboratories. This tool measures the cognitive effort and emotional components of engagement in given tasks to generate data that instructors can use to determine whether or not to revise or continue the use of a given activity. Wiggins et. al warn that this tool must always be triangulated, as it is intrinsically subjective and captures only some components of student engagement. In this action research study, laboratory protocols were rewritten with the jigsaw method and evaluated through a modified ASPECT survey, professorial observations, and student interviews and focus groups to determine the impact on student engagement.

Statement of the Problem of Practice

Of the 2,706 students enrolled in Fall semesters of the 2015-2017 beginning biology courses at NCC, 1,029 earned a D, F, or W (withdraw) but there is no direct understanding of what impacts student success in this course at NCC. Additionally, NCC students report lower than average rates of active and collaborative learning compared to benchmark institutions on the CCSSE but the CCSSE is a top-down, institutional granularity way to examine the problem. The goal of this action research study is to investigate the impact of jigsaw methods on student engagement at the individual student grain size in the beginning biology laboratory.

Research Question

Careful delineation of research questions is necessary in action research for efficient planning. Because action research is a spiral, clear rotation around the axis of defined research questions keeps the project focused on improving student outcomes (Mertler, 2013).

Research Question 1: How does the use of the jigsaw method in the beginning biology laboratory impact student engagement?

Understanding answers to this question will inform the development of an action plan designed to remediate any inequities in the classroom. Further investigation of this question will lead to other questions, ultimately and continually improvement of pedagogy in accordance with action research methodology (Mertler, 2013).

Purpose Statement

The primary purpose of the present study is to investigate student self-perceptions of their cognitive and affective engagement as jigsaw method protocols are used during Fall 2018 and as students complete a modified ASPECT survey.

The secondary purpose is to triangulate survey data with professorial observations of behavior, spontaneous and semi-structured interviews with the student-participants, and focus groups to determine the validity of the modified ASPECT survey findings.

The tertiary purpose is to design an action plan with the student-participants to craft beginning biology curriculum recommendations for NCC.

Rationale

I have taught and sought to improve outcomes in the beginning biology course for many years. Despite the hundreds of hours that I and my coworkers have spent with students in this laboratory, we consider there to be further room for improvement in this course.

There exists circumstantial evidence that curriculum such as the laboratory book can frame student thinking or habits (Bazzul, 2015). If the NCC beginning biology curriculum impacts student engagement, then it is imperative to rewrite curriculum in order to increase the likelihood of student success in the laboratory.

An introduction to the proposed research method follows with a more detailed plan outlined in Chapter Three.

Methodology

Action research summary. According to Mertler, "Action research is defined as any systematic inquiry…for the purpose of gathering information about how their particular schools operate…and how their students learn" (2013, p. 4). Action research encourages educators to critically analyze the interactions of their students, experiment with new practices, and take risks in the interest of improving student learning. We improve courses through observing the current situation, reflecting, collecting data, and implementing an action plan for improvement based on that information. This implemented action plan in a recursive spiral then becomes the current situation for the next loop of the spiral allowing a systematic progression to continuously improve practice. This action research project will seek to observe student behaviors and comments as they use the current laboratory protocol, reflect on the findings, and develop with student participation an action plan for intervention.

The professor-researcher. The professor-researcher is a white, late 30s, master's-degree holding heterosexually married woman with one young child who has been teaching professionally for 17 years. Students perceive me as an outsider due to my upbringing in a different part of the country, but I am an insider in the classroom generally trusted by students as demonstrated by their willingness to complete work and succeed. Mertler (2013) tells us that action research is a never-ending process of looking, acting, observing, and acting again. I have been working to improve outcomes in the laboratory for several years.

The student-participants. It is the experience of the professor-researcher that students are usually earnest, well-meaning, and well-mannered. NCC students range in age from high school to retired with an average age of 27. Twenty-eight percent of the students are self-identified "ethnic minorities." During Fall 2018, 36.7% of beginning biology students needed remediation in English, math, and/or reading. Students are more likely to be women than men. Sixty-seven percent of students receive some financial aid. Only 14% of NCC students graduate in three years, and success rates reveal a racial disparity.

The action research design. Altmann (1974) writes that the formulation of a research question informs the method of data collection. For this action research project, the research question is "how does the use of the jigsaw method in the beginning biology laboratory impact student engagement?" The goal for this project is to understand whether or not jigsaw method effects are strong enough to warrant investment of time to overhaul all biology laboratory protocols at NCC.

This research question lends itself to quantitative data as the primary dataset with supporting qualitative data for triangulation. Qualitative and quantitative methods each have their strengths and flaws. Using strengths of both qualitative and quantitative methods allows the development of deeper insight than can be understood from using only quantitative or qualitative methods alone (Creswell, 2013).

Quantitative research demands an objectivity that is often impossible in an educational setting, especially when the researcher is embedded within the context as occurs in action research, and in this case where the modified ASPECT survey is subject to student recollections (Wiggins, Eddy, Wener-Fligner, et al., 2017). Numbers cannot always capture the full depth of human experience, behavior, or motivations (Johnson & Onwuegbuzie, 2004). An action researcher who sticks to the numbers loses some of the necessary depth to understand complex people in complex systems.

Qualitative research could be accused of allowing bias or emotion to cloud one's clear thinking (Johnson & Onwuegbuzie, 2004). A professor may be inclined to think the best of her students, perhaps forming a type of halo effect or Panglossian classroom where we think we have the best of all possible students. However, observational studies allow the students and professor to collaborate in a more open-ended fashion to explore the ramifications of the question as they occur. Essential to this collaboration is trust between participants (Mertler, 2013). Action research is collaborative between the student-participants and the educator-researcher (Mertler, 2013). Senge (2012) writes that the only people able to see the entire school system, the students, are often the most insightful with the best ideas for improvement. Student-participants, in this study, are essential, as is the qualitative methodology used to elicit their ideas.

Data was collected via several means in order to determine the impacts of jigsaw methods on student engagement. While students worked together in the laboratory, the professor-researcher collected field notes as to which students exhibited which signs of behavioral engagement. Initial coding included observing body language (turned to or away from the group), and activity (on task or not, such as using a cell phone to message friends). Immediately after the conclusion of laboratory, participating students were asked to complete a modified ASPECT survey investigating student self-reports regarding their cognitive and affective engagement. Spontaneous and semi-structured interviews occurred during and after laboratory sessions in order to elicit student thinking at the time of and with reflection after the activity. The professor-researcher kept a data collection journal with analytic memos.

Following the collection of data, an action plan was developed through focus groups with student-participants. As it was determined that jigsaw method decreased student engagement compared to standard protocol weeks, the action plan is to more tightly link the lecture and laboratory components of the class and provide better professional development and support for beginning biology professors.

Ethical considerations. Dana and Yendol-Hoppey (2014) indicate that good and ethical teaching requires professors to watch students to look for any patterns in behavior that might affect how well they learn, and then to adjust to those patterns for better outcomes. Once aware of a potential problem detrimentally impacting students, I am obligated to observe my students. If it is indeed a problem for my students, then I am obligated to find a solution. I would be required to do this regardless of whether or not I made it an action research project. As Dana and Yendol-Hoppey write, "…choosing *not* to engage in the process can almost be viewed as *un*ethical" (p. 149). Should I be aware of problems detrimentally impacting students but fail to take actions within my sphere of influence to solve them, then by my own ethical standards I am not behaving properly.

At the beginning of the semester, a consent letter was provided to students. Only students who chose to return the signed waiver were included in this action research study. Institutional Review Board (IRB) waivers gained from the University of South Carolina and approved from NCC permitted this study. Student information was anonymized and kept confidential. Identifying data was changed to protect privacy.

As planned, my action research methods and observations did not interfere with student learning. Students are used to and expect me to watch them work, and I only made notes in my researcher role when not performing in my educator role. I did not require students to participate in the study. I did not ask students to do anything outside of their usual classroom responsibilities.

Potential Weaknesses

Assumptions not verified to be true. Students are assumed to be generally good and kind people who have an interest in equitability and make best-faith efforts to learn. The professor has assumed that her intrinsic biases were overcome or mitigated in her efforts to improve student outcomes through periods of intense self-reflection and conversations with students.

Limitations. As the time for this research study was short, the project was limited to merely a few weeks of observation and results and for this reason could not include course outcomes. Research was only conducted on one campus, the most urban of the four. Conclusions drawn from an urban campus may not apply to more suburban campuses but it was not feasible to study the more distant locations.

Scope. The action research was conducted only with Fall 2018 students at NCC. Other students at other colleges might not show the same results or find useful the same action plan.

Conceptual Framework

In this section the guiding critical theory for this action research project is elucidated. I relied heavily upon constructivism as briefly described here with further literature review in Chapter Two to determine my intervention technique and interpret my findings. Although my action research project led me into many niches, all these niches were subsumed under the umbrella of constructivism.

Constructivism is a philosophy of learning that prioritizes the social interpretation of experiences with roots in Dewey and Vygotsky (Doolittle, 2014). Dewey's view of learning is realized when students share their experiences to *construct* knowledge (Bruffee, 1995; Schiro, 2013) with four characteristics as described by Örentürk, Göktas, and Bulu (2004):

1. Learners determine their own learning.

2. Learning happens based on what learners already know.

3. Learning happens in social contexts.

4. Learning is based on authentic tasks.

As laboratory activities at NCC lend themselves well to open-ended inquiry by students, social group work including discussion of outside experiences and meaningful tasks per the above four characteristics, I targeted the beginning biology laboratory as the most impactful place for change especially as compared to the more solitary nature of the beginning biology lecture. I then needed to identify how I could make the already existing group work better and so turned to Vygotsky.

Vygotsky (1978) also recognized that social experiences and authentic tasks influence learning but prioritized the conversational aspect of social interactions where Dewey prioritized the communal (Popkewitz, 1998). Vygotsky's writings informed my choice of observing student engagement as a proxy for learning. Student engagement was approximated in this action research project with the three factors of behavior, cognitive effort, and emotion as described by Fredericks, Blumenfeld, and Paris (2004) to determine the impact of the intervention.

Vygotsky wrote, “the most significant moment in the course of intellectual development… occurs when speech and practical activity… converge” (Vygotsky, 1978, p. 24). Vygotsky described young children learning through interaction and speech, priming the professor-research to look for similar interactions in the beginning biology college students. When I observed my students spending most of their time either engaging in tasks or speaking to each other about the tasks, I understood that these were behavioral and cognitive signs of learning as informed by Dewey and Vygotsky and constructivism.

Vygotsky also informed my reliance on the emotional component of student engagement. His concept of perezhivanie, or the affective impact of educational experiences (Mahn & John-Steiner, 2002), was continually reflected by my students through their actions and in their emotional self-reports, especially when these emotions influenced whether or not group of students were able to demonstrate behavioral or cognitive engagement as described in Chapter Four of this DiP. Along with the behavioral and cognitive signs of activity and constructive dialogue, student emotions reflected the sense-making of experiences described by constructivism as essential to student learning.

As an ethical professor I could only engage in action research if it did not detrimentally impact student learning (Dana & Yendol-Hoppey, 2014). As such, any intervention or research question I investigated had to rest on potentially best practices for inducing learning. If we accept that students learn through meaningful experiences, discussion about these experiences, and positive emotional and social relationships per the tenets of constructivism, then the role of an educator is to set up conditions conducive to this experience (Schiro, 2013). A literature review revealed a jigsaw technique where students are individually responsible for tasks but must work together to succeed (Colosi & Zales, 1998) as a potentially effective constructivist pedagogical technique. Because jigsaw technique is well-grounded in constructivist theory, I chose it for my initial intervention for this loop of the action research spiral (Colosi & Zales, 1998; Mertler, 2013; Orenturk et al., 2004).

The Significance of the Study

Improvements that can be embedded in the written laboratory book were prioritized, as this book impacts over a thousand community college students and their professors across two campuses of NCC each year. This course was chosen over other biology courses because it is the first biology course for approximately half the students at NCC. Any improvements in student outcomes at beginning biology has the potential to positively impact thousands of students as they continue on to their goals.

The professor-researcher made the results available to the community at large through the publication of the dissertation and frequent conversations with students and interested coworkers. The professor-researcher took a leadership role at her school to discuss findings with coworkers concerned about similar disparities in their own classrooms. The action plan supported by this action research project is potentially applicable to all professors in all science laboratories at NCC.

Conclusion

Jigsaw methods do not impact student engagement in the beginning biology laboratory at NCC enough to warrant my time in converting our existing labs yet in the process of conducting this study it was learned that students had strong ideas about learning. Student responses on a modified ASPECT survey were combined with professor-researcher observations and student-participant voices to analyze potential curricular improvements and develop an action plan. In this chapter, rationale and conceptual frameworks were outlined and assumptions and potential weaknesses were examined. This study is expected to immediately apply to students attending two of the four campuses at NCC but has anticipated applications to all students in all laboratories.

Glossary

In this section, vocabulary relevant to this DiP is disambiguated.

Active learning – "any instructional method that engages students in the learning process" (Prince, 2004, p. 223).

Action research – "Any systematic inquiry…for the purpose of gathering information about how their particular schools operate…and how their students learn" (Mertler, 2013, p. 4).

ASPECT survey – a student self-report survey designed specifically for higher education seeking a tool to evaluate the impact of active learning activities on student engagement (Wiggins, Eddy, Wener-Fligner, et al., 2017)

CCSSE – The Community College Student Survey of Engagement (CCSSE). The CCSSE is an instrument that community colleges across the United States use for benchmarking against peer institutions, evaluate institutional effectiveness, and target areas of improvement. (“CCSSE - About CCSSE,” n.d.).

Jigsaw method – A technique where students are divided into groups. Each member of this group becomes responsible for a specific subtask and it is only by working together that a group may accomplish its goals. (Griffin & Howard, 2017).

Laboratory protocol – As used in this DiP, the directions provided to students to complete a given laboratory procedure. At NCC, these protocols exist in a free book that is given to them at the beginning of the semester.

Student engagement – A metaconstruct consisting of behavioral engagement (how students act), cognitive engagement (how hard students apply themselves to the task), and emotional engagement (the feelings the students have regarding each other and the material) (Fredricks et al., 2004)

Student success – Although student success can be defined by grades or retention, graduation, or placement rates (Kahu & Nelson, 2018), for the purposes of this action research project student success is internally defined by NCC as a student ending a course with a C grade or better.

Chapter 2 Literature Review

As described in the previous chapter, student outcomes from the beginning biology course at Northern Community College (NCC) are low and CCSSE scores on active and collaborative learning are lower than benchmark colleges. There is room to improve. The research question (RQ) asks “how does the use of the jigsaw method in the beginning biology laboratory impact student engagement?” The purpose of this Action Research (AR) study seeks to determine if existing laboratory curriculum should be modified to include more frequent use of a jigsaw method through investigating changes in student engagement via observations, a survey, and spontaneous and semi-structured interviews. In this chapter, the literature influencing understandings of the PoP is reviewed.

The Literature Review

Machi and McEvoy (2016) define a complex literature review as that which summarizes a body of research to unearth directions for new study. In order to answer the RQ, one must understand what is known about how and why students behave in science classes as well as what is not known or where uncertainty exists regarding this behavior. By analysis of what is and is not known and examination of conflicting evidence, this literature review will inform the intervention taken to solve the PoP at NCC. This literature review seeks to present an introduction to peer-reviewed research papers, theoretical books and book chapters necessary to understand the intricacies of the

PoP and proposed intervention. Related literature was found by searching key terms in ERIC, EBSCO, and Google Scholar. Reference analysis of most relevant papers and theoretical books was conducted in order to find additional literature and to develop an understanding of the dialogue on topics related to the PoP. I envision the research literature as a nodes and path network. Some nodes are frequently cited authors, some lines of thinking can be thought of as pathways. This literature review strives to describe a useful map of this network to the visitor regarding this PoP.

This chapter provides a curated overview of the underlying framework informing my thinking of the problem, an investigation of active, collaborative, and cooperative learning, the theories behind student engagement and why it is desirable to increase but difficult to evaluate, and an introduction to the jigsaw methods. This review of the literature is organized by the following main sections: (a) theoretical grounding, (b) active, cooperative and collaborative learning, (c) student engagement, and (d) the jigsaw method.

Theoretical Grounding

Constructivism was the primary framework guiding all steps of this action research project. The primary framework informs the ways of thinking about the problem and avenues to investigate to find solutions (Lederman & Lederman, 2015).

Constructivism is generally rooted in the writings of Dewey, Piaget and Vygotsky. Dewey wrote that education came about through social experience but these experiences must be of good quality to foster learning (Dewey, 1998). In this AR study, the professor-researcher is attempting to evaluate the quality of the educational experience in the beginning biology laboratory in the interest of fostering good learning as evaluated through student engagement.

Piaget started as a biologist but shifted his interest to cognitive development for most of his career which spanned multiple disciplines over fifty years (Fosnot & Perry, 1996). Piaget argued that while social experiences are necessary for human cognitive development, true learning was facilitated in the disequilibrium that occurred between what the learner expected and what actually happened (as cited by Palincsar, 1998). While Piaget described stages of cognitive development resulting from different types of disequilibrium, his framework suggested that these changes stabilized in the teen years in a formal operational way of thinking that remained static through adult years (Bass, 2012).

One limitation from Piaget is although he was interested in how students learn, he did not prescribe an educational environment (Sjøberg, 2007). Vygotsky (1978) bridges this, echoing Dewey (1998) that social interactions are essential to student learning, but adds that they must be expanded to explain student success (Hodges, 2018). Two aspects of an educational environment, in Vygotsky's description, must be considered. Perezhivanie, the positive emotional impact of educational experiences including support from the community of learners (Mahn & John-Steiner, 2002), and the use of speech to describe thoughts (Vygotsky, 1978) should also be scaffolded for the ideal learning environment. The beginning biology laboratory was chosen for my efforts to improve student learning because the laboratory is already set up to foster positive group work with speech. However, I want to know if the social interactions in the laboratory can be improved to increase the chances of student success.

In constructivism, the role of the curriculum instructor is to create or develop authentic tasks with meaningful context (Ertmer & Newby, 1993). For example in the beginning biology laboratory it is not enough to ask students to practice using graduated cylinders for the sake of measuring. Instead, a constructivist curriculum designer would embed the use of graduated cylinders in a greater task so the measurement becomes necessary to completing the work. This task would be further embedded in a social situation to facilitate critical reflection or discussion between students.

Constructivism is a useful method for teaching complex and integrated topics (Ertmer & Newby, 1993) such as occur in my beginning biology laboratory. The group format and the ability to spark cognitive dissonance and resolve truth through discussion about scaffolded experiences in this laboratory suggests constructivism could yield a path for improving student experiences. In the next section specific constructivist techniques are considered.

Active, Collaborative and Cooperative Learning

Although active, collaborative, and cooperative learning are all rooted in constructivism (Anthony, 1996; Panitz, 1999), there is much confusion in the literature about the difference between active, collaborative, and cooperative learning. The Community College Survey of Student Engagement (CCSSE), a benchmark survey widely used by American community colleges to identify areas of potential improvement ("CCSSE - About CCSSE," n.d.; McClenney, Marti, & Adkins, 2012) conflate active and collaborative learning in their measurements but do not indicate which operationalized methods might result in which outcomes ("CCCSE - Initiative on Student Success -

Student Quotes," n.d.). Instead, CCSSE proponents merely write, "…students learn more when they are actively involved in their education and engage in joint educational efforts with other students" (McClenney et al., 2012, p. 4). In contrast to the CCSSE, Machemer and Crawford (2007) distinguished cooperative learning as a subset of active learning. They write, "…active learning is 'doing', cooperative learning is 'doing with others'" (p. 11). In the beginning biology laboratory at NCC, active learning might ask students to analyze their pulse before and after exercising. Cooperative learning might ask students to take each other's pulses, exercise together, and analyze the data together. It may be possible for students in an active learning laboratory to avoid speaking to anyone else but it would be impossible to do so in a cooperative learning laboratory.

Further confusion comes in attempting to clarify cooperative and collaborative learning. Jacobs (2015) writes that, although some authors see collaborative learning as student-centered and cooperative learning as being teacher-centered, both terms are more similar than different in terms of moving away from a teacher-talking type of classroom and should be considered synonymous. Alternately, Bruffee (1995) considers cooperative techniques to apply more to younger children and collaborative techniques to refer more to college students.

In the following section, the three terms are disambiguated as much as possible and the research is briefly reviewed.

Active learning. Active learning is defined by Prince (2004) as "…any instructional method that engages students in the learning process" (p. 223). In a literature review, Prince suggests that active learning can be as simple as embedding some small activities into lectures.

Other authors found active learning to be more onerous. Machemer and Crawford (Panitz, 1999) considered problems with active learning to include demands upon faculty time to create activities, taking away time from lecture that could have been used to cover more material, difficulty in evaluating the activities, and student resistance to becoming active. Machemer and Crawford investigated student perceptions of active learning techniques in large general education university courses over four years to find that students did value lecture and active learning but only if they could see how the activities translated to exam scores. These students scored collaborative learning as least desirable compared to lecture and active learning. Despite the student perceptions, actual exam outcomes were better for active and collaborative learning compared to traditional lecture, suggesting that being able to cover more material does not necessarily result in students retaining it and simply asking students how they feel may not be adequate in determining technique efficacy.

Prince (2004) suggests one reason why research investigating the effectiveness of active learning is contradictory is because researchers do not always clearly delineate what they mean by active learning. This is true of Machemer and Crawford (2007) who only vaguely defined how they operationalized their concept of active learning. Prince further warns that even when terms are clarified, effect sizes are small and when a method requires such significant input of instructor time, a wise instructor might wish to consider whether or not time spent in preparation is worth the student output. A final warning from Prince indicates that even if one instructor at one college found gains, another instructor at another college might not see those same gains because of the variety in contextual factors. Most faculty who publish active learning gains are comparing to traditional lecture methods (Prince, 2004), but my beginning biology laboratories have never had a strong lecture component and therefore, most research on active learning is automatically not relevant to my particular context. If Prince is correct, it justifies my plan to carefully investigate the use of the jigsaw technique in only a few weeks with a few students before investing significant time into wide application.

While active learning methods are well supported as effective and desirable (Machemer & Crawford, 2007; McClenney et al., 2012), the lack of consensus in the term makes it difficult to determine whether or not instructor time should be invested into improving active learning methods in the learning environment (Prince, 2004) Active learning can be considered an umbrella term for any way of teaching and learning that includes student engagement in the learning process, which includes both collaborative and cooperative learning (Prince, 2004). In the next two sections, collaborative and cooperative learning will be considered.

Collaborative learning. Bruffee (1995) argues that collaborative learning was originally designed for use by college and university students. Although both collaborative and cooperative learning techniques are designed to help students work together on cognitively complex and valuable tasks, Bruffee considers the responsibility for group work to fall more heavily on the instructor in the primary and secondary classroom with cooperative techniques. If the goal is for students to take primary responsibility for learning, and if dissension (such as rejecting a teacher's point of view) is viewed as an important factor in developing student ownership of knowledge, then collaborative learning is better suited for college students in Bruffee's taxonomy. Panitz (1999) directly responds to Bruffee stating that although the two methods may have originally been meant for different populations, over time the distinction has become blurred and irrelevant. Panitz mentions that many teaching and learning techniques such as the jigsaw method can be classified as either collaborative or cooperative without fundamentally changing the nature of the activity.

Faust and Paulson (1998) consider collaborative learning to be a more inclusive term than cooperative learning. Collaborative learning in the Faust and Paulson taxonomy would refer to any situation where students work together, such as currently sometimes occurs in my beginning biology laboratory, but cooperative learning specifically refers to positive interdependence as described in the next section.

Cooperative learning. Cooperative learning comes from social interdependence theory and the early 1900s when psychologists were theorizing group dynamics (Johnson & Johnson, n.d.). Deutsch (1949) extended the concept by describing social interdependence as having positive, negative, and neutral outcomes which were bidirectionally impacted by the quality (positive, negative, or neutral) of interactions between group members. Cooperative theory in learning languished until the 1960s, when Johnson and Johnson resurrected the term and established the Cooperative Learning center at the University of Minnesota to clarify, operationalize, and implement cooperative learning in primary and secondary classrooms (Johnson & Johnson, 1999).

Johnson and Johnson clarify that simply putting students in a group and asking them to work together does not result in cooperative learning (Johnson & Johnson, 1999).

Instead, students must be obligated to work together to accomplish goals. Five elements categorize cooperative learning: (a) positive interdependence, where students perceive they are linked together and will not succeed without each other, (b) individual accountability, where each person is responsible for the success of the group, (c) face to face promotive interaction, where students help each other to achieve, (d) social skills including leadership and communication, and (e) group processing where students reflect on how well they are achieving their outcomes. Beginning biology at NCC is designed ostensibly for group work but does not currently require students to work together in all cases.

Cooperative learning is considered to be significantly correlated to student success. In a literature review of the technique specifically restricted to biology teaching, Lord (2001) describes positive impacts of cooperative learning on:

- how students think about science,
- how students feel about science, and
- how students generalize social skills to non-biology environments.

Lord continued to describe how cooperative learning provides extra opportunity for low-stakes formative assessment and immediate intervention from group members when students are confused. Lord concluded that the positive outcomes more than outweighed the extra time that it took to create cooperative learning activities. Alternately, Peterson and Miller (2004), while using experience sampling to investigate the impact of cooperative learning on undergraduates in a large psychology course, criticized many of these findings as “unverified claims for the benefits of cooperative learning” (p. 123) but did find that the use of cooperative learning techniques did appear to be better at keeping students on task compared to traditional lecture methods. Herrmann (2013) argued that although the positive impacts of cooperative learning are well verified at the primary and secondary levels of American school, solid evidence regarding college students "is still limited" (p. 175), and this may support Bruffee's (1995) claim that the terms should be delineated by student age.

In a review of the literature surrounding what is known about cooperative learning in higher education, Herrmann (2013) identified problems with cooperative learning as including concerns about weaker students being carried by stronger, student resentment and resistance to being dependent on peers, and conflicts when peers were perceived as interfering in outcomes such as good grades. Furthermore, college students reported cooperative learning as less valuable compared to lecture unless they were directly connected to exams or other grades, supporting the finding of Machemer and Crawford (2007). Herrmann, who was investigating cooperative learning and Danish undergraduates, suggested that students in higher education are grade focused and competitive and consider only lecture to be good teaching. Herrmann found the use of cooperative learning in weekly tutorials alongside political science lectures did not trigger the deep learning changes hoped for. Ultimately, Herrmann recognized the potential for cooperative learning groups but warned that teachers should expect resistance and structure the activities to be at an appropriate cognitive difficulty with clear linkages between the activity and the assessments. Herrmann and Machemer and Crawford both indicate that any learning techniques used in college learning environments must be tightly linked to outcomes and assessibility or students will regard them as useless.

Active, collaborative, and cooperative learning. When literature cannot come to a consensus as to how the terms should be delineated, this DiP will regard collaborative and cooperative learning to be fundamentally the same and to be subsets of active learning. Furthermore, when research regarding the use of collaborative and cooperative learning is focused primarily on the dichotomy of "lecture centered vs. group work centered," but the work in my beginning biology laboratory has always been group work centered, it is not clear from the literature whether or not improving the quality of group work in my beginning biology laboratory will result in better student outcomes. The next section of this Chapter Two literature review will investigate the impact of student engagement on student outcomes and consider a way to measure student engagement.

Student Engagement

Like the terms active, collaborative, and cooperative learning, student engagement is a messy construct which has not been well-operationalized. And, also like active, collaborative, and cooperative learning, the research is in near agreement that student engagement is a desirable quality to increase but specific applications vary. This section will describe the history of student engagement as a construct, describe several of the more common conceptualizations, and describe the current state of assessment of student engagement on institutional and student grain size levels.

Student engagement, detangled. Student engagement is not well defined. While most researchers agree that student engagement is a multidimensional construct made up of subconstructs, there is little agreement on how many or which components make up student engagement (Axelson & Flick, 2010; Kahu & Nelson, 2018). In this section a brief history of the term and confounding issues are described concluding with how the term is to be used for this DiP.

Appleton, Christenson, and Furlong (2008) reviewed literature regarding student engagement. They found that student engagement had only two literature references prior to 1985 and for the next few years nearly all published definitions included only behavioral and emotional components. Behavioral components would refer to how a student behaves in class, how hard they work, and if they are participating in activities. Emotional or affective components describe how the student feels about the activity, learning, and the school. Around the mid-2000s, most researchers began to include a third component regarding cognitive effort, similar to an idea of time on task and effort made in trying to understand the work. A few researchers at this time even included a fourth component usually referred to as an academic type potentially including concepts such as self-regulation and having goals about learning. By the time of their 2008 article, Appleton, Christenson, and Furlong had identified 19 related but individually unique definitions of student engagement.

Kuh (2009) philosophically describes student engagement as being both a reflection of how much time and effort students put into educational work but also what the institutions do to encourage and invite student participation in those activities. Alternately in the same year, Wolf-Wendel, Ward, and Kinzie (2009) attempted to develop a definition of student engagement by interviewing experts on college students identified through a literature search. Questions asked participants to disambiguate engagement from similar concepts such as involvement and integration. Literature review results and interview responses were triangulated with member checking to develop findings. Participants in this study concurred with Kuh (2009) (who was one of the participants and who cited Wolf-Wendel et al. in his own 2009 paper) that student engagement includes a measure of student effort on task as well as how institutions organize themselves to promote meaningful student effort. Key to this definition is recognizing engagement as a dialogue between student and institution. Experts in this study called for institutions to reflect deeply on their practices to develop optimal conditions for student success (Wolf-Wendel et al., 2009) as I sought to do in this action research study.

Kahu and Nelson (2018) recognized the continuing problems with the term student engagement and proposed a definition as, "an individual student's psychosocial state: their behavioral, emotional, and cognitive connection to their learning" (p. 59). Kahu (2013) describes this engagement as occurring variably depending on interactions between characteristics of the student, characteristics of the institutional environment, and the sociopolitical context. In this view, institutions and representatives of that institution, such as educators, are able to influence engagement.

A confounding factor in understanding student engagement is differentiating between student engagement and motivation or the reasons informing a student's choice of behavior. However, motivation tends to be thought of as an individual inclination where engagement is considered to be the outward demonstration of that motivation

(Fredricks & McColskey, 2012). Motivation and engagement tend to co-occur, although questions about which comes first persist (Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012; Reeve & Lee, 2014). Motivation was not directly investigated in this study in the interest of keeping constructs as tightly focused as possible.

Axelson and Flick (2010) side stepped the entire definition problem by changing the question. Arguing that the messiness of the construct occurs because it is used both as an accountability measure as well as a "variable in educational research that is aimed at understanding, explaining, and predicting student behavior in learning environments" (p. 41), they call for researchers to be specific as to which aspects of student engagement they are interested in during any given moment. In this DiP I have cited CCSSE data (engagement as accountability measure) as justification for questioning my role as researcher-educator in learning environments. To follow Axelson and Flick's (2010) guidance and for the purposes of this DiP, students in the beginning biology laboratory at NCC were evaluated using Fredricks, Blumenfeld, and Paris's (2004) tripartite framework of behavioral, emotional, and cognitive components. Under this model, behavioral engagement refers to participation in educational activities. Emotional engagement refers to the positive and negative feelings that occur between students, educators, and the institution. Cognitive engagement refers to how much of the self is invested in the educational work.

In contrast to Kuh's (2009) and Wolf-Wendel, Ward, and Kinzie's (2009) attempts to develop a definition of student engagement, Fredricks, Blumenfeld, and Paris (2004) suggested the term instead be reserved as a metaconstruct encompassing subconstructs. I have attempted to do so in this DiP. I restricted this study to only these three components or subconstructs as these three are still widely used (Henrie, Halverson, & Graham, 2015; Kahu & Nelson, 2018). This is not to say that the academic component is not important to student engagement but rather that practical factors involved in data collection caused a feasibility limitation. Given that the academic component is even less-well operationalized than the overall construct of student engagement, given difficulties involved in obtaining IRB approval at NCC as it was, and given the short time available for data collection, an agreement was reached with the relevant IRB parties at NCC that no grades or academic indicators would be used for this action research project.

Assessment of student engagement. In addition to the difficulty of defining student engagement, there are also difficulties in accurately assessing it. This ranges from the problems of multiple granularities, multiple definitions as described above, and the intrinsically subjective nature of many of the measures. In this section the problems are further delineated and best possible options are described.

Assessment granularity. There are many ways to measure student engagement, from the small grain size of the student to the large grain size of the institution (Sinatra et al., 2015). The National Survey of Student Engagement (NSSE) was first deployed in 1999 in the attempt to measure "student behaviors highly correlated with many desirable learning and personal development outcomes of college" ("NSSE survey_development," n.d.), which includes 10 engagement indicators ("NSSE Engagement Indicators," n.d.) and provides national benchmarks regarding what NSSE refers to as institutional quality. The NSSE has spawned several specialized but similar surveys including the Community College of Student Engagement (CCSSE) specifically designed for the needs of community colleges ("CCSSE - About CCSSE," n.d.) which is used at NCC. Both NSSE and CCSSE seek to assess student engagement (McCormick & McClenney, 2012) defined as being what the students do (Axelson & Flick, 2010). The CCSSE active and collaborative learning benchmark has been found to positively correlate with college graduation rates, student retention and persistence, and grades (Price & Tovar, 2014). The NSSE and CCSSE were an important shift in the views espoused by Mosher and MacGowan (1985) that engagement is something intrinsic to the student to the more modern view that student engagement can be influenced by the climate of the school (McCormick & McClenney, 2012). Other advantages of the NSSE and CCSSE are that they are research-based, identify potential areas for improvement to faculty and administrators, and results can be compared across colleges (McCormick & McClenney, 2012). Although there have been criticisms of NSSE and CCSSE, the criticisms themselves have been criticized and the surveys are generally considered reliable and valid when used appropriately (Pike, 2013).

Although the NSSE and CCSSE ask questions probing the use of active and collaborative learning and results are actionable on an institutional scale, it is sometimes difficult for individual faculty practitioners to know exactly which active or collaborative learning techniques should be used at the smaller grain size of the classroom if the faculty interest is in improving student engagement, and, therefore, student outcomes. The ICAP (sometimes known as DOLA) framework attempts to link cognitive engagement theory to specific activities used in the college classroom. In this framework, learning materials are hierarchically categorized as passive → active → constructive → interactive with each tier improving cognitive engagement and student learning outcomes. Student behaviors are combined with student products to identify how cognitively engaged a student was while doing an activity (Chi et al., 2018; Chi & Wylie, 2014; Menekse et al., 2013). Although theoretically well supported (Chi et al., 2018; Wiggins, Eddy, Grunspan, et al., 2017), attempts to teach K-12 teachers to implement ICAP as a bridge between institutional theory and classroom practice did not work well even after five years of professional development. Often planned classroom activities did not show results congruent with intent, assessments did not match activities, and students did not always operate at the levels expected by the teachers. The greatest difficulties occurred as teachers strove to implement interactive activities (Chi et al., 2018). Recognizing the difficulties of doing it well, the ICAP framework still informed the choice of a jigsaw technique for the intervention described in this DiP.

Methods for assessing engagement. Even after a potential intervention has been chosen, it is still difficult to assess engagement. Fredricks and McColskey (2012) reviewed several methods of assessing student engagement including experience sampling, interviews, and observations, concluding that self-report surveys are the most commonly used instrument. One example of self-report surveys include the Student Course Engagement Questionnaire (SCEQ) which strove to assess student engagement at the micro level rather than the "macro level" (Handelsman et al., 2005, p. 184) of the NSSE. While the SCEQ is multidimensional and links student engagement to student learning outcomes, the given dimensions of performance engagement, participation/interaction engagement, and skills engagement (Handelsman et al., 2005) do not clearly map to other student engagement frameworks although they do cover the behavioral, cognitive, and emotional domains described by Fredricks, Blumenfeld, and Paris in 2004 (Henrie et al., 2015). A more recently developed self-report survey is the

Assessing Student Perspective of Engagement in Class Tool (ASPECT,) validated with biology students and specifically designed to help faculty members determine which classroom activities should be revised, kept, or discarded when the goal is to improve student engagement across cognitive and affective dimensions which are the hardest for an observer to identify (Wiggins, Eddy, Wener-Fligner, et al., 2017). The authors of ASPECT recommend that, given the intrinsically subjective nature of engagement reports, all engagement research be triangulated by multiple methods as has been done for this action research study.

Why student engagement is important. An abundance of research links student engagement, as defined broadly and assessed in a variety of ways, to positive student outcomes (Fredricks et al., 2004; Handelsman et al., 2005; Kahu, 2013; Kahu & Nelson, 2018; Sinatra et al., 2015; Wiggins, Eddy, Grunspan, et al., 2017). These positive outcomes include persistence in STEM majors and careers (Gasiewski et al., 2012; Sinatra et al., 2015), post class quiz activities (Menekse et al., 2013), and graduation rates (Price & Tovar, 2014) although the exact mechanism by which engagement translates into student learning gains is still unknown (Kahu & Nelson, 2018; Wiggins, Eddy, Wener-Fligner, et al., 2017). The preponderance of linkages between student engagement and student learning outcomes indicates that a professor seeking curriculum improvements might want to investigate ways to increase student engagement within her sphere of influence.

Jigsaw Method

Throughout the literature on student engagement, active, collaborative, and cooperative learning, one method was frequently identified as potentially positively impacting student outcomes (for example, Chi & Wylie, 2014; Faust & Paulson, 1998; Mehta & Kulshrestha, 2014). This method, the jigsaw method, will be described here along with a review of the literature.

The method was first described by Eliot Aronson in the attempt to reduce prejudice between students in recently desegregated schools of the 1970s (as reported by Williams, 2004). In the jigsaw method, students are divided into groups. Each member of this group becomes responsible for learning a subtask. All learners of a subtask leave the home group to learn the subtask together. After each student has learned their subtask, they return to their homegroup and are either responsible for teaching the information to their groupmates or for performing the task so that the group as a whole can accomplish the goal (Griffin & Howard, 2017).

Jigsaw method in a biology laboratory. Colosi and Zales (1998) described an application of the jigsaw method that could apply to the beginning biology laboratory at NCC. College microbiology students were assigned to read a laboratory protocol prior to the scheduled period. They either completed a pre-laboratory assignment or took a quiz in the first few minutes of the laboratory period. After the quiz, rather than having a professor lecture over the work to be done, students were asked to assign numbers based on order of birth date. Laboratory protocols were divided into four jobs. Jobs were then assigned to students based on their number. All the #1s would briefly meet to discuss the tasks of their job, all the #2s would discuss theirs, and so on. Then the original group would reconvene to perform the day's activity, with each member empowered as the authority on their particular job. Over the course of the semester, tasks were rotated so all students had experience in all jobs. The authors reported that more students spoke up and dialogue was more meaningful with jigsaw methods. They eventually began using this method in more biology laboratories with different aged students but were at a university, a different environment from NCC.

Evidence for jigsaw learning. Slish (2005) investigated whether or not jigsaw learning resulted in better student grades than traditional lecture methods in a beginning nonmajors biology classroom. Not only were there no significant gains in class quiz averages, students reported that they strongly preferred the lecture method. However, Slish did not investigate whether or not students improved within demographic categories or report if there were any similarities in the 24% of students who preferred the jigsaw method. Nor did he apply this method to a laboratory setting such as is the interest in this action research study.

Crone and Portillo (2013) investigated jigsaw methods in college cognitive psychology courses and also showed no change in grades but did report an increase in student feelings of confidence which could improve science identity formation and therefore student outcomes according to Carlone and Johnson (2007).

Although Eddy, Brownell, Thummaphan, Lan, and Wenderoth (2015) recommended jigsaw methods to reduce bias in peer discussion groups, Amedu (2015) reported jigsaw methods benefited male students while harming female students based on pre-test post-test gains and recommended alternative methods be used to reduce gender bias. A possible explanation for this disagreement is that Eddy et al. were writing based on experiences with American college students while Amedu was describing results with Nigerian high school students. Another possible explanation for the conflicting results is that the younger students may have mandated attendance when college students have more leeway in their decisions to attend a given session. Unhappy college students might skip class or drop the course before completing a questionnaire.

There is some concern that as the jigsaw method was originally created specifically to reduce interracial bias in American primary and secondary schools (Williams, 2004), this method may not work as well with adult learners or for other content. Bratt (2008) proposed that if there are positive outcomes from jigsaw technique then they might be found in younger students rather than older. This view was supported by Leyva-Moral and Riu Camps (2016) who found European nursing students younger than 22 felt the method improved their learning but those older than 22 thought it a waste of time that increased their already high workload. Griffin and Howard (2017) found that Irish psychology students in their last year before earning a bachelor's degree rated this method as least effective in increasing their participation when compared to lectures with active learning activities, in-class presentations, and online discussion forums, possibly because shy students were least comfortable with the technique.

Jigsaw activities could be integrated into the existing curriculum without a loss of instructional time (Colosi & Zales, 1998). As described in the previous section, this activity shows mixed success in higher education but sometimes results in student gains. Given that the literature cannot definitively predict whether or not widespread adoption would be worth the investment of time, it was chosen for this AR project as a potential intervention for improving student engagement in the beginning biology laboratory.

Conclusion

In this chapter, the theoretical frameworks surrounding the problem of practice and proposed intervention were investigated. Theories of active, collaborative and cooperative learning were described and defined. The problems and benefits of student engagement were described and potential operational definitions were proposed. The jigsaw method was chosen as a particular intervention to address the problem of practice at NCC because of its potential success in higher education biology courses, its grounding in constructivism, and because it would not require an onerous investment of time or money. In the next chapter, the specific methodology used to determine whether or not the jigsaw method was an effective intervention at NCC will be described.

Chapter 3 Methodology

Introduction

This chapter will describe the action research design of the study. Action research seeks to improve education by connecting theory with practice as the practice occurs. Practical change blended with reflection and analysis is used to justify pedagogical choices through a cyclical process of planning, acting, observing, and reflecting (Mertler, 2013). In this chapter, the Problem of Practice will be reviewed and the research design will be explicated and justified

Purpose and Problem Statement

Students in beginning biology at NCC have low student outcomes and lower than benchmark active and collaborative learning scores on the CCSSE. The purpose of this study was to investigate the impact on student engagement when a jigsaw method protocol was used in three biology labs in Fall 2018. After exposure to the modified protocol during which I collected field notes on behavior and collected responses to the modified ASPECT survey and spontaneous interviews, I then conducted semi-structured interviews with the student-participants to centralize their perspectives and triangulate findings. Next, we collectively designed an action plan to improve beginning biology at NCC through focus groups. Specifically, the following research question guided my investigations: How does the use of the jigsaw method in the beginning biology laboratory impact student engagement?

Overview of the Literature

As described in more detail by Chapter Two of this DiP, constructivist philosophy informed the decisions made for this AR study. Constructivism, as described initially by Dewey and Vygotsky, describes learning as occurring when students participate in social experiences with positive emotions, discuss the experience, and integrate the experience with their prior knowledge (Doolittle, 2014; Mahn & John-Steiner, 2002; Orenturk et al., 2004; Vygotsky, 1978).

Specific pedagogical techniques relying on constructivist theory include active learning, collaboration, and cooperative learning (Anthony, 1996; Panitz, 1999). The Community College Survey of Student Engagement ("CCCSE - Initiative on Student Success - Student Quotes," n.d.) does not distinguish the terms although Machemer and Crawford (2007) consider cooperative learning to be a subset of active learning. Pantitz (1999) argues there is no real difference in the terms collaborative and cooperative learning but Faust and Paulson (1998) consider cooperative learning to require interdependence of students for success. In literature reviewed for this DiP, the jigsaw method was frequently described as an example of constructivist, active, collaborative, and cooperative learning depending on the author (for example, Chi & Wylie, 2014; Faust & Paulson, 1998; Mehta & Kulshrestha, 2014). In the jigsaw method, students are asked to become experts on subtasks which must be united for success of the group as a whole (Colosi & Zales, 1998). Although evidence for its effectiveness is somewhat mixed (Crone & Portillo, 2013; Eddy et al., 2015; Griffin & Howard, 2017; Leyva-Moral & Riu Camps, 2016; Slish, 2005), it is a relatively simple method to implement without significant loss of instructional time (Colosi & Zales, 1998), and, as such, was investigated as a potential intervention in this action research project.

Student engagement is also confusingly defined but for the purposes of this DiP the term is considered a metaconstruct encompassing three subconstructs of behavioral, cognitive, and emotional engagement as described by Fredricks, Blumenfeld, and Paris (2004). Student engagement is strongly linked to many desirable student outcomes including persistence and graduation (McCormick & McClenney, 2012; "NSSE survey_development," n.d.; Price & Tovar, 2014). Engagement is assessed at the institutional level by the NSSE and CCSSE (McCormick & McClenney, 2012) and assessed in the classroom through experience sampling, interviews, observations, and self-report surveys (Fredricks & McColskey, 2012).

A good teacher is ethically obligated to consider "…what adjustments can be made to instruction to help *all* students learn" (Dana & Yendol-Hoppey, 2014, p. 148). Action research dictates one must be reflective in one's teaching methods (Mertler, 2013). To this end, the ethical professor-researcher must reflect – what decisions do I make about curriculum that are not effective for my students, and how can I do better? This action research study seeks to determine the impacts of the jigsaw method on student engagement of beginning biology students at NCC, with a secondary purpose to determine an Action Plan with the help of the student-participants. This chapter describes the research design of the project and is followed by findings in the next chapter.

Research Design

In this section, the rationale for the research design and methodology will be described and impacts of decisions regarding research design are discussed.

Justification of action research methodology. Action research allows for the engagement of problem solving in a way that traditional research concerned with theory does not. Action research allows one to study the problem at the same time as one attempts to improve upon practice (Mertler, 2013). As a professor cannot teach from outside, and as research must be conducted to understand a problem, action research permits the professor-researcher to operate within both roles and to implement solutions as soon as is feasible (Mertler, 2013). Because I needed to conduct research without impacting normal teaching and learning activities, an action research framework was chosen to study the problem of student laboratory task assignment. Following Mertler's 2013 delineation of action research methodology, four stages of identifying a problem to focus on, collecting data, analyzing the data, and developing a plan of action were conducted for this DiP. Planning was conducted between 2015-2018. Data from observations, spontaneous and semi-structured interviews, a modified ASPECT survey, and focus groups requesting student voices were collected during Fall 2018, at which time the students and I developed an action plan. Reflections continued into early 2019.

Quantitative methods rationale. The appeal of quantitative methods comes from its apparent objectivity. However, this objectivity is often not actually attainable in an educational setting (R. B. Johnson & Onwuegbuzie, 2004). In this case, the modified ASPECT survey can yield useful insights as to how students feel and think about activities but use of the modified ASPECT survey sometimes may catch student biases. For better validation of findings, the survey's creators recommend using multiple sources of data to triangulate the quantitative data, including qualitative observations and interviews, to best understand student engagement (Wiggins, Eddy, Wener-Fligner, et al., 2017). This action research study was initially conceived as a primarily quantitative study with qualitative triangulation but when data was analyzed, qualitative results provided greater insight into student behaviors, emotions, and cognitive effort, and yielded a clearer path to development of an action plan.

Qualitative methods rationale. Because action research is participative and collaborative (Mertler, 2013) and because student-participants are important stakeholders in the development of an inclusive community, qualitative research methods allow participants the opportunity to describe their perceptions as to what is happening in the laboratory in their own voices. Mertler recommends the use of qualitative action research when the educator-researcher believes there are multiple versions of reality depending on the point of view of a given person and when a low structure for exploring themes is desired, as in this study. Creswell and Creswell (2017) recommend the use of qualitative methodology when there is a problem that needs to be explored, as we have in the beginning biology class where previous attempts to improve the curriculum have failed. It was through the use of qualitative methods that true insight into the problem was found in this study.

Creswell and Creswell (2017) describe the key components of qualitative research as beginning with theoretical frameworks such as constructivism and the domains of student engagement, the use of an emergent inquiry approach where questions elicit more questions, collection of the data in natural settings such as our laboratory rather than a stranger's laboratory, and an inductive and deductive data analysis aimed at finding themes or patterns. It is essential that the final story include the student-participant voices, transparency in my positionality, a thick, rich description of the problem, and a plan for action. These components were included in the design of this study, as well as further elaborated in Chapters Four and Five as findings and interpretations are described.

Emergent design of the study. Qualitative studies are iterative, beginning with a preliminary collection of data through observations, and in this case through quantitative survey results. In this action research study, these data led to decisions about who to invite to interviews, and what to ask them (Mertler, 2013). As the study continued, the important topics for the focus group emerged.

Setting of the study. Northern Community College (NCC) is a moderately large community college located in Moderately Large (ML) city in a Northern state. One in three of the adult residents of the surrounding county have attended at least one class at NCC since 2000. Women make up 57% of the student body, the average age is 27 years, and 29% of students self-identify as ethnic minorities.

NCC consists of four campuses and five smaller centers, somewhat equally spread around the greater metropolitan area. The biology class in this research study is offered at all four campuses and three of the centers. The central campus is located within the city and draws more diverse students compared to the suburban campuses.

Students in this course greatly vary in terms of interest, motivation, and ability as understood from my professional experience from the past 16 years teaching this course.

Beginning biology is required by students enrolled in 21 programs. It is usually taken in the first semester by allied health students as it is a prerequisite to all subsequent biology courses. It is usually taken in a later or last semester by criminal justice and social work students who come to biology with some trepidation, putting off the class as long as possible, but who have more developed academic abilities. A third population in this course comes from advisors who frequently recommend this course to students who do not yet have defined academic or career plans, due to its wide applicability to so many majors.

Students frequently cannot afford costs of several hundred dollars per class for books which is why there is an in-house lab book written primarily by me with some input from coworkers. We use this book with approximately 1,000 students per year at three NCC locations. It has been used for several years in its current form with very few complaints. Students are able to follow directions and successfully complete both weekly labs and the semester. The current lab book does not currently contain any direction as to how students should approach task assignment, nor does it have direction on how students should identify tasks. Students are supposed to work in groups but can choose not to do so.

Positionality. As no human researcher can ever be completely objective, the next best position is to become aware of personal biases informed by identity and experience and how they may influence one's perspective. One must reflect upon biases in order to overcome them to become the best possible educator. I disclose my background here and kept a reflective action research journal during the period of data collection for transparency (Ortlipp, 2008).

I have been teaching biology in community college systems for 17 years, 16 of those years at NCC. My parents, who serve as ethical think leaders for their community, brought me up to believe that one should use one's talents to better the world for the people around us, a belief further developed and reinforced by my attendance at a Quaker college with a social justice focus for my undergraduate degree and then strengthened by my very first experiences teaching community college. I continue to have deep interest in issues surrounding social justice as evinced by my decision to work at the community college level and the projects in which I engage. I fiercely believe that all individuals should have opportunity to succeed to their potential. I am white, approaching middle age, and heterosexually married with one child. Additionally, I am neither from Moderately Large city, nor speak with the regional dialect used by students here, and I am regarded as a tolerated or welcomed outsider to the broader community. I believe that it is the role of curriculum, and my role as curriculum designer, to meet the educational needs of students. If students are not succeeding, the flaw is in my curricular design.

In order to be effective as a professor and a researcher, I must have a warm rapport with students so they will feel comfortable to open up enough to share their thoughts. I must have a deep understanding of the dynamics at play in the field to lend credibility and nuance to my conclusions. By reflecting upon potential biases, member checking, asking appropriate interview questions, and deeply analyzing results, I can lean on the strengths of being the research instrument while mitigating the potential threats. (Poggenpoel & Myburgh, 2003)

Data Collection Methods

Students were provided information at the beginning of the semester regarding their potential participation in the research study. After notification they were only included in the study if they returned a signed consent letter, which 43 students did. The informed consent letter was approved by my advisor at the University of South Carolina as well as by the in-house IRB panel at NCC (see Appendix A).

Data were collected in multiple ways to allow polyangulation (Mertler, 2013): through field observations, maintenance of an action research data collection journal, informal interviews, semi-structured interviews, a modified ASPECT survey, and focus groups. Data was collected over a six-week period according to the schedule followed in Appendix B.

Three daytime sections met at 11:00AM on Tuesday, Wednesday, or Thursday of each week. Students were generally similar in terms of exhibiting the wide variety of background normal to this course. Students selected their own groups and efforts were made by the professor-researcher to allow the groups to remain stable over the course of the semester in accordance with recommended practices (Theobald et al., 2017).

Each week, the laboratory protocol was rewritten in a jigsaw fashion and applied to one section while the other two sections continued to use the existing laboratory protocol. The jigsaw protocols were written for four students, each of whom would take primary responsibility for a specific role over the course of the day. Students were assigned tasks based on the order of their birthday. The tasks were initially called director/time keeper, assembler, scribe, and reader. The director/time keeper was responsible for telling the other three students when to do their tasks which included timing incubations of experiments. The assembler put together laboratory materials to run experiments, such as placing sugar inside a potato for observation of osmosis. The scribe was responsible for writing answers to a laboratory assignment, which included questions where all lab members were asked to provide an opinion. The reader was responsible for reading and referring back to the background material necessary for understanding the laboratory observations. The assembly, laboratory assignment questions, and reading material were identical to that of the standard protocol in the same week. The major difference was that the standard protocol had been taken apart into four handouts such that each student could only see one piece. If a group had fewer than four students, two jobs would be combined by one student.

The data collection methods, their strengths and weaknesses, and their applicability to the AR study of this DiP are described in what follows.

The modified ASPECT survey. Immediately after laboratory was finished and before the semi-structured interviews began, students were asked to complete a modified ASPECT survey regarding cognitive and affective engagement. Self-report surveys are a common way to assess student engagement because they are practical, easy, and cheap. In the interest of encouraging honesty, the surveys were kept anonymous (Fredricks & McColskey, 2012).

The ASPECT survey was designed for higher educational professionals to evaluate the engagement impact of active learning activities and was validated on first-year biology students. The original survey consists of 16 items assessing student perceptions regarding the value of the activity, the personal effort put forth, and the perceived impact of the instructor's efforts. Cronbach's alpha for these three domains were 0.91, 0.84, and 0.78 respectively (Wiggins, Eddy, Wener-Fligner, et al., 2017).

As I was investigating whether or not embedding the jigsaw method into written protocol for use by all instructors should be a recommended best practice for NCC, I eliminated all questions on the original ASPECT survey regarding instructor impact. I modified the language of the questions where necessary to use language familiar to students (for example, changing the phrase "group activity" to "lab activity") and removed a few questions to shorten the survey to better meet anticipated student attention spans. Results were subject to basic statistics using Excel. My modified ASPECT survey is available in Appendix D.

Observations. Students were observed using a checklist for brief measures of behavioral indicators of body language (turned to or turned away from the group) and actions taken (on task or not) with space for unstructured description. They were also observed via field notes taken as they worked.

Checklists. I used a simple checklist (see Appendix C) to help focus my field observations. Checklists are lists of behaviors where I simply indicated that a thing did or did not happen (Mertler, 2013). The checklist was developed as I thought about common laboratory behaviors that I thought might indicate engagement. I made the checklist in advance of collecting data and, during the post-lab interviews, asked students if my interpretations of their actions were correct in order to member check my decisions and in the interest of eliciting any student engagement processes I may have missed such as internal thoughts. Although it may have been ideal to member check the checklist with students before collecting observations, I did not want to tip off students about the true interest of the study, as students had only been told that I was collecting data to improve the course.

The advantages of using this checklist were that I could quickly observe multiple students concurrently with minimal disruption to their work. These quick checklists allowed faster data analysis. The disadvantage of using these checklists was that I lost some data depth because of the spot-check nature. I attempted to regain data-depth as well as member check through the use of informal and semi-structured interviews during and after the laboratory session. The percent of on-task students was calculated with a calculator. Further descriptive statistics were not conducted for reasons explained in Chapter Four of this DiP.

Field observations. In situations where the topic of interest is challenging for participants to articulate, observations can be a strong way to determine whether or not actions are occurring regardless of the awareness or social norm inclinations of the participants (Ritchie, Lewis, Nicholls, & Ormston, 2013). However, observations did not indicate what students were thinking or how hard they were working (Fredricks & McColskey, 2012) and so they were regarded as secondary data for the purposes of triangulation and providing deeper insight of phenomena and, after initial coding and analysis was performed, proto-findings were member checked with students during focus groups.

Although I was a participant in the educational setting, I was not a participant in group work, and so my role in this case was as participant-observer (Rossman & Rallis, 2003). It is acknowledged that the presence of the observer can affect the behavior of the observed (Ritchie et al., 2013). For this reason, I established a pattern from the second week of the semester where I floated between various workgroups bringing my own work or a notepad with me while students worked instead of remaining at the instructor desk. I sat at each student table for a time, watched students work, asked them questions, answered their questions, worked on my grading, made notes on extraneous things on my notepad, watched groups at other tables and, after a time, circulated to a different group to repeat the process. I attempted to spend very little time behind my desk so students would become used to my interest in their activities. This behavior is normal for me in all semesters, as I find that it helps build rapport and divert confusions better than when I stay behind my desk. Although this circulation pattern increased the number of interactions between the professor-researcher and student-participants, the student-participants did not consider the close presence of the professor to be unusual in the weeks in which observational data was collected, as recommended by Ritchie, Lewis, Nicholls, and Ormston.

During data collection weeks, I continued my established circulation pattern but instead of grading had a notebook in a portfolio for capturing field notes. I attempted to write as much as I could during each laboratory period, writing nearly constantly except when speaking with students. The portfolio was used to cover my notes when not writing in order to preserve confidentiality and to prevent students from being tipped off as to the nature of my observations. Students did not comment on my data collection except in the case of one student who may have had special needs who appeared to become fixated. His group members would seek to redirect his attention during these times in what I interpreted to be a very kind support of my efforts.

Informal interviews. Informal interviews are questions which provide important insight into student perceptions spontaneously asked at the time a behavior occurs (Coll & Chapman, 2000). Informal interviews can be thought of as akin to conversational efforts to collect and validate data (Wimpenny & Gass, 2000). The downside of informal interviews is that it easy for the data collected to be patchy and difficult to analyze compared to questions asked in semi-structured interviews (Coll & Chapman, 2000; Mertler, 2013). As students worked, they were occasionally asked spontaneous open-ended questions by the professor-researcher regarding their thinking and feelings. Again, due to the potential bias of the professor-researcher and the student-participants including social desirability concerns (Fredricks & McColskey, 2012), this was considered secondary data for the purpose of polyangulation. For this reason, in this AR study informal interviews were primarily used to identify students for further semi-structured interviews and for very quick checks of professor-researcher field note data.

When informal interviews were conducted, questions were asked to add immediate nuance to an observed behavior at the time the behavior occurred. Face-to-face questions asked were generated spontaneously as the professor-researcher watched student activity. Various students were asked why they performed an action, what they were thinking, how they were feeling, or any other questions in response to their own volunteered information. Not all questions asked of students were relevant to this AR study in order to obscure specific interests and also to maintain a classroom environment that was not disrupted by data collection. Questions were open-ended to allow wide latitude of student responses (Mertler, 2013). All students were questioned at least once in each lab period to obscure interest in particular experiences and because it is normal for me in non-data collection weeks to attempt to speak to every student individually at least once each period. Most questions were asked at times to avoid interference with student learning (Dana & Yendol-Hoppey, 2014). When it appeared that student perceptions contained more depth than could be answered quickly without interfering in student learning, student-participants were invited to stay after class for short semi-structured interviews.

Semi-structured qualitative interviews. Semi-structured interviews have a deliberate focus with open-ended questions to allow for the input of student-participants in their own words with their own ideas. The goal of semi-structured interviews is to deepen understanding of phenomena. Ideal answers are in-depth and detailed, and follow-up questions aid in the collaboration of a shared meaning between the professor-researcher and student-participants (Galletta, 2013). Roulston (2010) suggests that interview quality be judged by whether the interview data answered the research questions, when both the interviewer and the student understood each other's meanings, and if the questions elicited rich answers.

Two problem with interviews is that students may have framed their answers to look good in the eyes of someone who held the power of grades over them and my own biases may have structured the types of questions I asked. In the interest of generating the best possible valid interview data despite concerns about interview validity, I framed these interviews very carefully. I asked students open-ended questions in language they were likely to understand, asked them if they felt they understood me, answered their questions when they asked for clarification, and when I did not understand their answers, I asked for clarification. I tried to talk a little and listen a lot (Roulston, 2010) and, after asking initial questions to start students speaking, restricted my comments to reframing what I had heard to confirm my understanding, asking further questions, or providing answers to direct questions.

Short semi-structured interviews occurred during or immediately following laboratory sessions. Student-participants were occasionally asked why they performed an action with follow-up questions as needed to deepen responses or elicit further information. Many interviews were initiated by asking, "Why did you decide to perform (that action)?" Other interviews were initiated by asking, "What were you thinking about when you did (that action)?" In some cases, students were asked, "What did you think "focused" meant on the survey?" or "What do you think it means to have fun in a laboratory session?" in order to check that students were interpreting survey questions the same way I did. Follow up questions were generated based on student responses.

Semi-structured interviews lasted from a few minutes in the case of relatively quick questions but in a few cases became over an hour long as students shared strong emotions, nuance, and depth in their answers. Although semi-structured interviews were originally intended to be one student at a time, there were several times when students preferred to stay with their partners and answer together. These interviews with two students at a time led to greater depth as students explored their different perspectives with each other and sense-making in a co-constructionist sense could be observed occurring in real time.

As students volunteered private data that I was sometimes able to confirm in other ways, such as by speaking with shared lecture instructors, I believe they were as honest as it was possible for them to be. Given that most semi-structured interviews yielded very detailed accounts of sometimes personal events, I do not think my bias or influence significantly restricted student comments. This is in accordance with Roulston's (2010) guidance that quality qualitative interviews have participants and a researcher who are "reliable and accurate" (p. 217).

The aim of the semi-structured interview questions was to elicit student ideas about behaviors close to the time it occurred and to probe for consensus on the meaning of survey items. Responses were recorded, transcribed, and coded by the professor-researcher to identify themes.

Action research data collection journal. My Fall 2018 schedule was deliberately chosen to leave me unencumbered time immediately before and after each of the sections of beginning biology for this important reflective work. Each week before the first section met on Tuesday, I reviewed my data collection plan for the week, notes from the previous weeks, and reflected on my short-term goals through this journal. During laboratory sessions, I was primarily focused on recording student voices and actions but when possible, I made quick notes on my own perceptions and thoughts. Immediately after each section's post-lab semi-structured interviews concluded and the students left, I took quiet moments to write a longer entry on what I thought had happened, beginning ideas about coding or findings, and questions for the next session. I stayed attuned to places where my interpretations could vary, as it was through identifying my beliefs and subjectivities that I would become more adept at recognizing those of the students (Ortlipp, 2008). The goal of this journal was to record my reflections at the time of events (Mertler, 2013), as well as to check for continued progress on the data collection plan. After the data was collected, this journal became a helpful tool to help me understand how my understandings and practice had changed (Ortlipp, 2008).

Focus groups. In a focus group, student-participants are asked to share their views in a permissive, supportive environment. Interview prompts were given and both responses and observations of the group dynamics were recorded. Where semi-structured interviews allowed only for the viewpoint of an individual participant, focus groups allowed the creation of a shared narrative across the group as student-participants shared ideas with each other and as student-participants questioned and reframed the questions of the professor-researcher (Massey, 2011). In this AR project, focus groups also allowed for early themes to be shared with student-participants for reflection, deepening of themes, member-checking, and the development of an action plan.

All students who consented to participate in this AR study were invited to attend focus groups and several options were made available for attendance for approximately an hour each after normal laboratory schedule time. Eighteen students ultimately attended and represented a solid demographic cross section from the original 43 participants, in that women, men, and people from various races, nationalities, and backgrounds all were included. To demonstrate respect for student time and encourage participation, as well as to facilitate the development of a nonjudgmental environment, cookies were provided. Students were recorded and responses were transcribed and coded in the manner described below soon after conclusion of the groups. Questions for these focus groups were developed regarding themes coded from observations and short interviews. These observations were initially specific notes about individual student behavior, comments, and apparent emotion. As the weeks progressed, these notes emerged into more coherent findings regarding the three subdomains of student engagement, a process described in Chapter Four of this DiP. Using the initial coding from observations and student interviews, I developed conversation prompts for the focus groups as follows:

- I asked open-ended questions about behavioral, cognitive, and emotional domains of student engagement.
- I asked the students how they felt about the jigsaw activity and probed specifically to determine their cognitive, behavioral, and emotional perspectives.
- I asked about specific events that I had observed in laboratory to both check my own interpretations and to learn the interpretations of the students.
- Students wanted to compare laboratory and lecture with the goal of improving their success rates, so this conversational topic was explored as students volunteered observations.
- We worked together to construct an action research plan as described in Chapter Five of this DiP.

Participating students in three sections of beginning biology were observed and informal and semi-structured interviews were conducted during and immediately following three weeks as described in Appendix B. Focus groups were held during the subsequent week of Fall Semester 2018. All qualitative results were coded as described below.

Analysis of quantitative results. The modified ASPECT survey results and quantified checklist were collected in Excel and subject to basic descriptive statistics reported in Chapter Four of this DiP.

Analysis of qualitative results. Open-ended observational data and interviews were coded to look for patterns. All qualitative data was recorded, transcribed, and coded according to the following description.

Saldaña (2016) describes coding as the subjective but organized way data are collected under umbrellas of codes to find patterns of behavior in order to lead to interpretations of meaning. Codes in this study could refer to a data point unit of analysis as small as a student comment or as large as a short paragraph from my field notes. Codes are one word or short phrase descriptors that to capture the essential meaning of the data point. I followed Saldaña's description of eclectic coding which is recommended when data sources are diverse and segmented into small chunks as they were in this study.

During data collection periods in the laboratory period, I handwrote notes as students worked. During these times I begin to identify potential codes through analytic memos which were revisited week by week for follow up. I paid attention to what people were doing, what their emotional state appeared to be, my own place in the laboratory (to ensure I was correctly observing data but not interfering in learning) and anything else that struck me as worth writing down. Handwritten notes were transcribed into a Microsoft Word document immediately following the laboratory period and I would add further analytic memos as themes began to emerge.

After the data collection period, I split each data point from the typed field observation notes into a separate line in an Excel table. I coded my results iteratively in accordance with Saldaña's (2016) recommendations. My initial list of codes contained more than 50 items but not all items were relevant to the research question and other items, upon reflection, could be combined. By the end of the first formal iterative cycle I had about 30 codes. Although Saldaña suggests that different numbers of codes can be used, I found this number to be ideal and robust for focusing data points to inform my research question.

I next made a sticky note tree to assign each code to one of four categories. This sticky note tree became my codebook and was kept on my wall behind my laptop for frequent and easy reference while I reflected on findings. Categories in this tree corresponded to the three subconstructs used to describe student engagement: behavioral, emotional, and cognitive (Fredricks et al., 2004). These three categories were further subdivided as positive, negative, or neutral. An example of a positive behavior would be two or more students constructively engaging in laboratory activities. An example of negative emotional engagement would be students calling each other names. The fourth category flagged student comments, personal observations made as part of my analytic memos, or any other data point that I felt could be used to evaluate the validity and rigor of this study. All coding was subjective and focused to the research question, in accordance with Saldaña's (2016) guidelines. I then passed through the Excel list of data a second time to assign categories based on this tree, and, as I went, double checked that I still felt the codes matched the data points.

At this time, each line of the Excel table contained identifier data including the order of the phrase, the week it occurred, the lab section it occurred in, and the modality those students were experiencing at the time. Additional columns were added to track each assigned code, category, and my judgement as to whether in context it was positive, negative, or neutral. Please see Table 3.1 for how this appeared:

Table 3.1: A sample of the data after two rounds of coding in Excel.

Theme	Category	Code	Data	order	Week	Section	Modality
pos	emotion	smile	Chelsea smiling hugely with what seems like pride as she is slowly lowering the potato into the beaker	15	2	wednesday	jigsaw
pos	behavior	assembling together	Sherry says, “OK! Now use another toothpick or the scoop to push the potato off!”	16	2	wednesday	jigsaw
pos	cognitive	answering qs	...asks to use forceps	17	2	wednesday	jigsaw
neutral	cognitive	answering qs	Zeniah says from across the room, “Can we have a new potato?”	18	2	wednesday	jigsaw
neg	behavior	body language	Chantae says from her seat across the room, where she is shrinking backwards, curled into herself,	19	2	wednesday	jigsaw
pos	behavior	joking	laughing, “I have fat fingers.”	20	2	wednesday	jigsaw
pos	emotion	support	she shouts over her shoulder to her group, “We’ll get this sooner or later!”	21	2	wednesday	jigsaw
pos	emotion	smile	She is smiling	22	2	wednesday	jigsaw
pos	behavior	assembling together	Kiana and Zeniah are standing up and assembling the experiment	23	2	wednesday	jigsaw
pos	cognitive	creating	ask Sherry what she’s doing – she’s writing a lot on the back of a handout. She says, “I’m just rewriting the definitions like it says here (flips the paper to point at the learning objectives on the handout I gave everyone) so I can absorb it.”	24	2	wednesday	jigsaw

Excel functions were then used to sort by code and category columns so for the easy examination of patterns. For example, I could ask Excel to sort to show me all times students were positively engaged in a cognitive way. Resorting allowed me to check coding errors our outliers but no further refinement was needed. This sorting function also enabled me to quickly pull all data points relevant to a theme which assisted in discovering patterns and writing findings. Categories were linked back the themes of the subconstructs of student engagement allowing for analysis of data from multiple perspectives while evaluating student engagement in the beginning biology laboratory. These findings are summarized in Chapter Four of this DiP.

Trustworthiness of the study. In this study, a quantitative primary dataset was triangulated against qualitative methods including observations of student actions in laboratory, informal interviews at the time of behavior, semi-structured interviews with select students after laboratory sessions, and focus groups with 18 students the week after the laboratory observations.

To further legitimate the study, conclusions were member-checked with students and other professors who teach the same class for authenticity. Prolonged engagement and persistent observations have been demonstrated by the tenure of the professor-researcher in teaching this particular class and in her rapport with the students. Reports of qualitative data were thickly described. Peer debriefing requirements for legitimacy were met by the continued collaboration between faculty and students both at the University of South Carolina and NCC. This study was conducted according to norms as defined by the dissertation committed at the University of South Carolina, documented with the University of South Carolina ethical review board, was approved by the NCC IRB panel, and I maintained a sensitivity to my participants and my setting. These standards are defined by Rossman and Rallis (2003) as those components necessary to deem a qualitative study trustworthy.

Reflection. Mertler (2013) describes the reflection stage of an action research study as a time to reflect on results and share and communicate results. Reflection is a critical stage of the action research project, as one must feel confident in conclusions before acting in the next loop of the spiral or before communicating findings to others. Reflection for this AR study occurred through the end of Fall Semester 2018 and the beginning of Spring Semester 2019.

A primary component of continued reflection throughout this study was through the action research data collection journal. Secondarily, after the conclusion of the focus groups, I reflected as to the efficacy of the research study. I asked myself - did my results answer my research question? If not, what additional information did I need? If my results did answer my research question, what did I plan to do next? Was my study design appropriate for the questions I needed to answer? Was my question the right question, or did I need to ask different questions? How do I continually improve the classroom experience for all students? Discoveries of practice were sought for the opportunity to improve practice (Mertler, 2013) and for successful implementation of the action plan described in Chapter Five of this DiP. Results were shared with coworkers as opportunity arose through hallway conversations and meetings.

Conclusions and the Next Iteration of the Action Research Cycle

Action research is an iterative, unending cycle of observing, acting, and reflecting (Mertler, 2013). In this particular loop of the cycle, I gathered data on student behaviors and attitudes, attempted to construct a shared narrative to understand and improve the beginning biology course, reflected upon the findings, and with the student-participants, made decisions about how to improve practice as I continue in my attempts to improve outcomes for all students at NCC. Findings of this study will be discussed in the next chapter.

Chapter 4 Findings and Interpretations of Results

Introduction

In Chapter Four of this Dissertation, the findings of this study and interpretation thereof will be provided. This action research study used quantitative and qualitative findings to describe student interactions in the laboratory of the beginning biology course for approximately half the students at Northern Community College (NCC) in a moderately large city in a Northern state. This study attempted to understand and improve factors impacting student engagement.

Problem of Practice

In this Dissertation in Practice (DiP), the Problem of Practice (PoP) concerned the beginning biology students at NCC. Although thousands of students have enrolled for this course, only 62% have successfully completed it with a C or better and the reasons for why students do or do not succeed are not well understood.

NCC scores lower than benchmark community colleges on the student engagement component of the Community College Survey of Student Engagement (CCSSE,) a survey designed to assist community colleges in prioritizing efforts to improve student experiences ("CCSSE - About CCSSE," n.d.). Student engagement, undefined by CCSSE and defined as the tripartite model of behavior, cognitive effort, and emotions for this DiP (Fredricks et al., 2004) is linked to several student outcomes including student retention (Price & Tovar, 2014), indicating that improving student engagement could potentially improve student retention among other positive effects.

There are multiple ways by which student engagement might be improved. For this project, the jigsaw method was chosen because of its constructivist grounding as described in Chapter Two of this DiP. The jigsaw method has been suggested as a strong technique for improving student engagement by some studies (Chi & Wylie, 2014; Griffin & Howard, 2017; Hodges, 2018; Theobald et al., 2017) but not by all (Griffin & Howard, 2017; Leyva-Moral & Riu Camps, 2016). A literature review as described in Chapter Two of this DiP concluded that the jigsaw method appears to have variable impact depending on several factors which may or may not apply in the beginning biology laboratory studied by this action research project.

Purpose Statement

The purpose of this study was to investigate if using the jigsaw method in the beginning biology laboratory improved student engagement.

Design of the Study

Student self-perceptions of engagement on a modified ASPECT survey were triangulated with professorial observations and spontaneous and semi-structured interviews to determine the impact of the jigsaw method. Results were shared with students to create an Action Plan, which will be used to improve the course for all students enrolled in beginning biology.

Description of the Study

In this section, the ethics of the study, participants and the environment are described. The qualitative components of this study include field notes, student comments elicited through daily spontaneous and semi-structured interviews performed individually or in small groups during each of the nine days of observations, and student remarks from three focus groups conducted in the week following the three weeks of observations. The quantitative approach of this study included student responses on a modified ASPECT survey after the laboratory period for each day of observations.

Ethics of the study. Action Research studies have unique ethical concerns due to the embedded insider role of the educator-professor and because the Belmont protocol was originally developed for a different type of inquiry. However, while the ethical concerns of action research studies are real, the nuance, depth, and richness of data generated by insider-researchers is too valuable to ignore (Nolen & Putten, 2007).

An ethical question pertinent to this study is whether or not students truly felt free to choose and be honest when I asked for informed consent or other data. In accordance with Nolen and Putten's recommendations, I made it clear that students were free to opt out with no penalty and kept my word. I tried to keep the class as democratic as possible, actively recruiting student input as to how our class should run starting from the beginning of the semester long before the data collection period began. Also from the beginning of the semester, I worked at establishing trust with all students.

Given that a certain number of students opted out and other students shared very personal ideas, I believe there was enough trust in our laboratory for students to freely participate. I have left out all references to nonparticipating students in my data collection and reflections, as well as this DiP, but included all nonparticipating students fully in classroom matters so as not to penalize their education. Other steps taken to protect confidentiality including keeping all handwritten notes locked in a filing cabinet in a locked room when not in use, keeping my laptop with me or in secure locations at all times, using pseudonyms and misdirecting details to obscure identity, and I will destroy all notes and recordings one year from the completion of my doctoral degree.

At the end of the semester, several students thanked me for the degree of care and concern I had shown for them, commended me to other entities of the school and the community, and gave me hugs. I believe that my students felt supported and honored during data collection as well as the entire semester and they felt empowered to share their honest thoughts.

Participants. At the beginning of the semester, 72 students in three sections were eligible to participate in this study due to having elected to take a day-time laboratory section taught by me. After consent letters were signed and returned and after some number of withdrawals, 43 students remained participatory. These students were observed by me as they worked. In each section in each week, each laboratory table including participatory students were interviewed spontaneously. At least one but sometimes two or three students were interviewed after each of nine laboratory meetings in semi-structured format. These students were chosen when something happened that caused me to want to know more about their thinking but I did not want to interrupt their laboratory work. All participating students were invited to one of three scheduled focus groups and eighteen students were willing and able to attend. Member checking of data including survey results, observations, my emerging findings and initial conclusions occurred during these focus groups. All participating students and pertinent co-educators were invited to read the dissertation prior to its publication. Some findings were verbally member checked with coworkers at various times during this action research process.

Participating students included 34 women and 9 men. One woman presented as female but indicated a more fluid gender presentation when not in class. Eight students were foreign born and 35 students were born in America. At least two students self-volunteered during the course of the study that they came from different regions of the United States. Seventeen students were black or multiracial, 19 were white, four were Middle Eastern, one was Latina, one was southeast Asian, and one was orthodox Jewish. Thirty students were in their late teens or early 20s, eight appeared to be in their late 20s, four were in their 30s or 40s, and one was in her 50s. One student volunteered that she is the first generation in her family to attend college but statistically, others probably were as well. Other students volunteered that they qualified for need-based grants. Although these demographics do not perfectly match course demographics, there were participants from the most frequently observed groups at NCC.

Students worked in groups of two to four people. Groups were chosen by students as they came into the laboratory on the first day and decided where to sit. Lei, Kuestermeyer, and Westmeyer (2010) determined that students tend to pick groups based on who they know and who they perceive to be similar, which is indeed what appeared to happen in NCC. Most groups remained consistent for the entire semester. I moved Chantae, a young black woman, from a table with two white women in their late 20's to a table with two other black women (one young, one a grandmother) and a late 20's white woman, after observing tensions before this study began. Makin, a late 30's Middle Eastern man, requested to stop attending his group with three teenage white women and instead began attending a different section.

Laboratory schedule. Three sections of beginning biology laboratory were included for this study. Data was collected in semester weeks 9, 10, and 12. Week 11 was excluded because the laboratory activity scheduled for that week was not an experimental protocol type laboratory. Weeks 9 and 10 included experiments pertaining to diffusion and osmosis, respectively, and are considered to be a two-part lab on membrane transport by the faculty of my department. Week 12 asks students to investigate respiration patterns before and after stimulus such as exercise or consumption of sugar.

Each section was asked to participate in one jigaw session. Although students in different laboratory sections sometimes know each other from sharing a lecture course, no students indicated advance knowledge of the week in which they received the jigsaw treatment. Students were exposed to the jigsaw treatment according to the following Table 4.1:

Table 4.1: Laboratory schedule demonstrating jigsaw modality rotation.

Laboratory Schedule	Tuesday	Wednesday	Thursday
Week 9 – Diffusion	Jigsaw	Standard	Standard
Week 10 – Osmosis	Standard	Jigsaw	Standard
Week 12 - Respiration	Standard	Standard	Jigsaw

Findings and Interpretations

In this section, the following findings and interpretations of the study are discussed in terms of their potential impact on student engagement as determined by this action research study. The research question sought to understand, "“How does the use of the jigsaw method in the beginning biology laboratory impact student engagement?” Collection of observations, interviews (spontaneous and semi-structured,) the use of the modified ASPECT survey, and focus groups revealed the finding that student engagement is higher during standard protocol weeks than jigsaw weeks.

Quantitative findings. Quantitative data showed that student engagement is normally high in standard weeks and is not improved by jigsaw laboratory protocols. Two types of quantitative data were collected for this DiP. A modified ASPECT survey, visible in Appendix D, was completed by student-participants after each of three laboratory sessions. Additionally, checklist "yes/no" observations of engagement and on-task behavior were conducted two or three times (depending on length of session) by the professor-researcher.

The modified ASPECT survey results. Aggregating all questions from this modified ASPECT survey yields an approximate measure of student engagement specifically in the emotional and cognitive domains (Wiggins, Eddy, Wener-Fligner, et al., 2017). Students completed this survey immediately after each laboratory session but before participating in semi-structured interviews, if invited. Survey results were calculated with basic mean formulas using Excel. The mean of all three jigsaw weeks was 5.1 out of six, compared to the overall mean of all standard weeks of 5.4.

In Tuesday's laboratory, the student engagement mean for the jigsaw weeks was 5.05 compared to standard weeks where the mean was higher at 5.5. On specific questions (available in Appendix D), Tuesday's students scored the jigsaw activity lower than standard protocol except on question 1, where students felt that explaining improved their understanding of laboratory material equally during the jigsaw week and the following standard week. Students felt explanations from group members were the worst in the jigsaw week (question 2) and rated the jigsaw week as the week in which they felt the least confident (question 6). Full results from Tuesday's students can be seen in Figure 4.1.

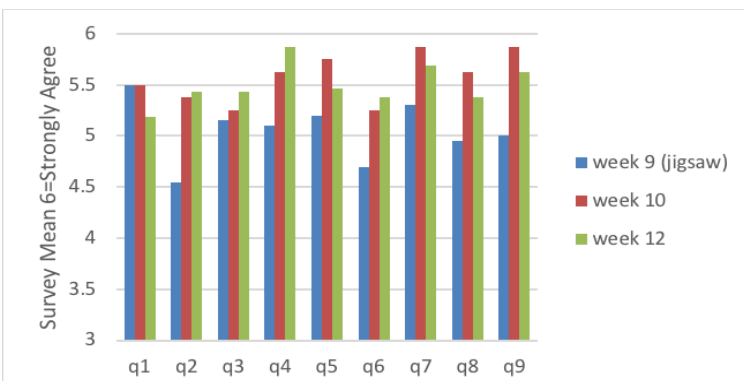

Figure 4.1: Tuesday Modified ASPECT Survey Results.

Wednesday's students also rated their jigsaw week the lowest for student engagement with the overall mean of 4.86 compared to the standard week mean of 5.45. Individual questions revealed very large dips in jigsaw weeks, as visible in Figure 4.2. Students in Wednesday's lab indicated the jigsaw week as overall the worst across all nine survey questions compared to their standard weeks. There was especially strong student disagreement in questions 2, 3, 4, and 5 which regarded student perceptions of their group members, but students also disagreed on questions 7, 8, and 9 regarding their own efforts.

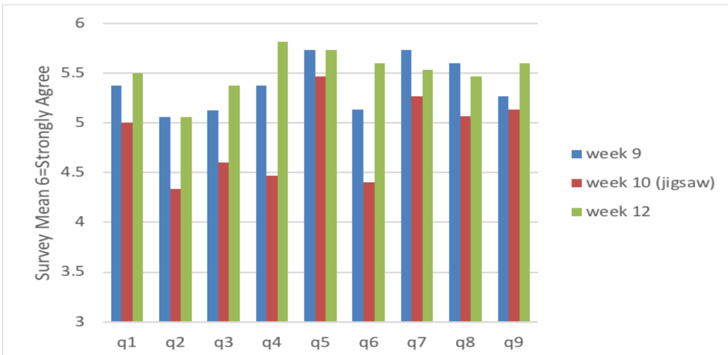

Figure 4.2: Wednesday Modified ASPECT survey results.

Thursday's students did not follow the trend set by the Tuesday and Wednesday students, rating their self-perceived student engagement in the jigsaw week most highly of the three weeks with a mean of 5.4. Thursday's student standard week means were 5.25. Individual questions did not reveal such deep dips during the jigsaw week for Thursday's laboratory.

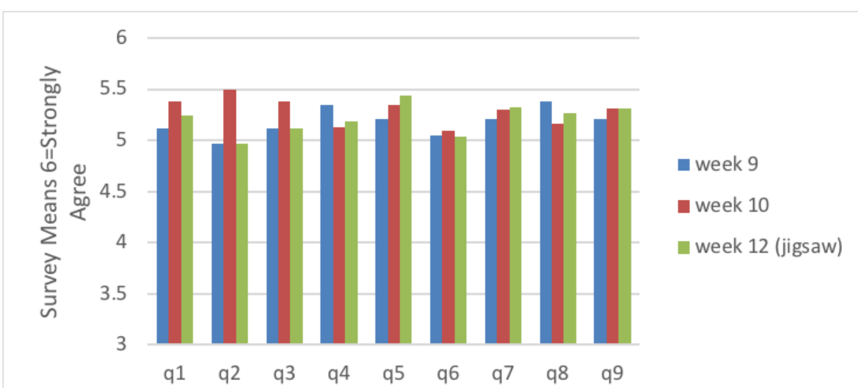

Figure 4.3: Thursday Modified ASPECT survey results.

Although Tuesday and Wednesday students showed clear preferences for standard methodology compared to jigsaw weeks as described above, students in Thursday did not show the same clear pattern as shown in Figure 4.3. It is possible that week 12 is a favorite lab of all students regardless of modality and the engagement depression effect observed in Tuesday and Wednesday labs was counteracted by this preference in lab material. Question 4 on the modified ASPECT survey addresses this when asking whether students had fun during lab. Comparing weeks across all three weeks as demonstrated in Table 4.2, student means indicated they perceived the most fun during the respiration week (5.8 compared to 5.3 where 1 = strongly disagree, 6 = strongly agree) when comparing only standard sections to standard sections. In all three weeks, whichever section had the jigsaw protocol rated it as less fun than the equivalent week in the two standard sections. Ultimately, Thursday's results cannot be explained as being due to the material covered in lab that week or the jigsaw modality used.

Table 4.2: Student means from a Likert-type scale (out of six) when asked how much fun they had during today's lab activity.

Question 4: I had fun during today's lab activity.	Standard	Jigsaw
Week 9 – Diffusion	5.3	5.1
Week 10 – Osmosis	5.3	4.4
Week 12 - Respiration	5.8	5.4

A different possibility explaining Thursday's results could be that I had learned to write better jigsaw labs by this point. After I observed students spending large amounts of time idle in the jigsaw weeks of 9 and 10, I had rewritten the week 12 jigsaw laboratory to have shorter periods of time between student hand-offs so each student could share the spotlight a little more frequently. Another difference was that in weeks 9 and 10, I had written the laboratory protocols so that each student "job" was very tightly focused. In week 12, I tried to spread the work more evenly. Because no section received the jigsaw treatment twice, it is not possible to compare modified ASPECT survey results meaningfully to determine if my jigsaw writing ability improved over time.

The modified ASPECT survey data revealed that perceived student engagement in the emotional and cognitive effort domains is normally higher in standard laboratory weeks and generally declined when jigsaw protocols were used. However, the survey's creators recognize flaws in this instrument including student bias, which may have occurred in week 12. For this reason, the survey's creators strongly recommend triangulation through multiple data collection methods such as the behavioral checklist and qualitative techniques including the interviews and focus groups (Wiggins, Eddy, Wener-Fligner, et al., 2017).

The behavioral checklist. Students were observed two to three times (depending on laboratory session length) during each of nine sessions using the checklist in Appendix C. Students were evaluated based on instructor perception of engagement as defined through body language (turned into the group or away) and behavior that was on task or not. The results were as follows in Table 4.3:

Table 4.3: Instructor perceptions of engagement using behavioral checklist.

Percentage on task and engaged	Tuesday Laboratory	Wednesday Laboratory	Thursday Laboratory
Week 9 – Diffusion	(jigsaw) 86%	98%	97%
Week 10 – Osmosis	90%	(jigsaw) 100%	81%
Week 12 - Respiration	93%	97%	(jigsaw) 94%

This data collection method was not as useful as anticipated prior to the data collection period. Students worked so quickly in most weeks, and students engaged in interactions so frequently with the professor-researcher, it was difficult to take more than two class measurements. I could never take more than three. When I took measurements, students might be on task at the time I looked at them but then immediately pull out a cell phone and start texting, leading to uncertainty in what should have been yes/no measurements. Students appeared to notice me the most when using this data collection method as evinced by the ways in which students did not react when I came to sit at their lab tables to collect field notes but would look at me when I moved behind the podium. It is possible that students are trained to watch for signs that a professor wishes to address a classroom, and, upon noticing my interest, found ways to look busy. Had I realized this faster I could have gotten better data by subtly taking these observations from a corner or without moving my location but would have had difficulty seeing everyone.

Additional factors may have impacted the reliability and validity of student engagement readings on this behavioral checklist. Students preferred week 12 to weeks 9 and 10 as demonstrated from my experience in previous semesters, the above modified ASPECT survey results, and their comments in interviews and the focus groups (to be described shortly). In Week 10, there are long periods of time where students have nothing to do but to wait for incubations to run, and many admitted to pulling out cell phones during the wait. Although I counted it as such, is it really off topic behavior if nothing else is available for them to do? Another error may have been introduced from the timing of when I used the checklist. I tried to take measurements around the same time (approximately every half hour) in each class but classes move at different paces and a measurement on Tuesday during an assembly phase of laboratory would reveal different numbers than a measurement on Thursday during an incubation period. Finally, students in week 10 were frequently discussing whether or not they should withdraw from the course, an emotional issue for some. By week 12 the withdraw date had passed and students who remained had made a fresh, recent commitment to the course by choosing to stay. My engagement observations picked up on a few students as disengaged who withdrew, but it also picked up a few students as disengaged who did not withdraw. For all these reasons, the behavioral checklist observations have so much uncertainty that I recommend they be ignored in the analysis of the findings for this research question. Student interviews (spontaneous and semi-structured) and focus groups were much better tools for determining what students think and feel as will be discussed next.

Qualitative field findings. For three weeks, I kept field notes with analytic memos and a journal of student activities, comments from spontaneous and semi-structured interviews, and my developing thought process. These data were coded according to engagement themes of behavior, emotion, and perceived cognitive effort as described in Chapter Three of this DiP. After the three weeks of field data collection, all participating students were invited to focus groups as described below.

When field findings were coded, themes of behavior, emotion, and cognitive effort appeared. These supported the quantitative finding that students are normally highly engaged in laboratory during standard weeks and jigsaw laboratory protocol did not increase student engagement. Behavioral themes included students working on laboratory materials, joking with each other, fidgeting, or playing with cell phones. Emotional findings included expressions of support ("cheerleading"), self-disclosure of personal information, or name calling. Cognitive effort themes included students answering riddles, engaging in constructive dialogue, creating ideas, reviewing their answers or the directions, or asking questions. Support for each domain's finding is presented here.

Behavior. The students in all sections spent most of their time engaged in laboratory related behaviors including assembling laboratory experiments, reading results, or recording results. Because notes on what student activities were made constantly (except when I was assisting students), observation showed with fine granularity that student engagement in the behavioral domain remains high across the entire laboratory period across all weeks and laboratory modalities.

Laboratory behavior patterns appeared to subdivide into assembly and discussion phases. During assembly phases, students would briefly discuss plans but often would operate independently of each other. I asked several students in spontaneous and semi-structured interviews how they decide who does what. Sometimes, students were so engaged in their task they didn't notice me at their table or hear my question and I did not receive a response. When students explained their process in standard weeks, it is that they decide who does what based on who they perceive to be best at a task. They also volunteered that they try not to stay idle. If they complete a task, they actively look for something else to do. I asked Chelsea and Christine how they decided that they would fill the tubes while Sherry and Fatima filled beakers. Sherry told me, "It's what we do when there are multiple things to do." Students wanted to stay busy.

During jigsaw weeks, students would spend time watching the assembler but would not volunteer to help. In semi-structured interviews some students shared that they were under the impression they were not allowed to help unless asked. Other students reported they had offered to help the assembler but were rebuffed. No student indicated that they liked watching one student do all the work. Some students complained that they did not like the enforced periods of idleness.

When I saw students appearing to do nothing, I asked them spontaneous interview questions about what they were thinking. In some cases, they were waiting for experiments to run. This is a problem in the diffusion and osmosis labs where there is a waiting period between the assembly phase and the discussion phase. In standard weeks, students would spontaneously (i.e. not at my direction) begin completing the postlab or next week's prelab together while waiting. In two groups, students found creative ways to use the laboratory materials and extend their learning, such as using their cell phones to take pictures of what they were looking at with the microscope or using the balances to weigh things from their backpacks. In jigsaw weeks, students would either sit silently during the waiting period or start text messaging people who were not in the classroom.

A surprising finding was how often students had their cellphones out. Although students are asked not to use cell phones as a matter of laboratory safety on the first day, I usually enforce this rule only when it is actually dangerous. Cell phone use was coded as either on-topic or off-topic. On-topic use of phones included as timers, calculators, portable textbooks, or consultation of the internet. Off-topic cell phone use included watching music videos, text messages, and in one case, a student who appeared to be watching a Facebook live video. On-topic cell phone use was considered positive behavioral engagement and off-topic cell phone use disengagement. This was confirmed through student focus groups. On-topic cell phone use occurred during all modalities, but off-topic cell phone use occurred far more frequently in jigsaw weeks.

In general, students demonstrated a high degree of behavioral engagement in all weeks according to the field notes. When students expressed disengagement by being idle, staring off into space, or texting, these behaviors were more likely to be observed during jigsaw weeks. Behavior is thought to be one domain of student engagement, but emotional and cognitive domains are also factors (Fredricks et al., 2004) and are described next.

Emotion. Coded emotional indicators included the use of emotion words such as “frustrated” or “excited” in student speech. Behaviors such as smiling and laughing were interpreted to be indications of positive emotional engagement in the laboratory (correlated through student interviews).

A pleasant surprise was the finding that students frequently encourage each other positively and supportively during standard laboratory sessions. For example, as Leila was trying to untangle an onionskin membrane, Tommie narrated, “You’re performing surgery… you’re doing it! Yes! You’re getting it! Just don’t poke holes in it! Look at you – you have a surgeon’s hands! You don’t even need me to hold it. We won’t have air bubbles this time. Yes!”

Students joked about laboratory when they were happily engaged. After Leila untangled the onionskin membrane, she said with a huge smile, “Look, no air bubbles – the operation has been a success.” Students often laughed at each other’s jokes even when the jokes were not very funny. Often after making a mistake a student would make a not-funny joke and be rewarded with laughter. This appeared to help the group move on past the embarrassment of the mistake and to focus on the learning.

Students also demonstrated care for each other and for me in standard weeks, as evinced by a student who noticed a band-aid on my arm, asked me if I had gotten my flu shot and then asked how I felt. When a student who may or may not have special needs needed extra help, his group members often anticipated this. They appeared to identify his confusion faster than he did, already moving with the laboratory materials while saying encouragingly, “I gotcha,” before he could articulate what he needed. These small expressions of care appeared to serve a similar function to the laughter, in terms of smoothing group interactions so groups could focus on learning.

Students were usually positive but sometimes were not. Negative emotions were expressions of disengagement but kind student support could assist to re-engage a student. For example, Summer made a mistake and called herself dumb six times in a row during a standard week. Chloe expressed a somewhat unkind sentiment about Summer’s mistake, but, when realizing that Summer could not complete the lab because she was so upset, Chloe changed her tone. Chloe provided a helpful suggestion for what Summer could do next and the two women managed to get back to work. Although Chloe was initially unkind, her emotional effort on behalf of Summer helped Summer persist in laboratory activities.

During jigsaw weeks, students frequently volunteered that they were bored or frustrated as I moved around the room. Celeste tried to be polite by asking me in what was probably intended to be a neutral tone of voice, “Will we have to do this kind of lab again?" When I said no, she cheered and then looked embarrassed. When negative emotional interactions occurred during jigsaw weeks, students would sit passively instead of emotionally engaging each other back to the work in the ways observed during standard weeks. Less kind interactions occurred, such as when a student frustrated by the jigsaw protocol observed that I had "pointy teeth."

In general, emotional observations indicated that students were happier and joked more often in standard weeks compared to jigsaw weeks. Students exhibited more frustration in jigsaw weeks that they indicated were due to the protocol and not due to other factors such as impending exams or withdraw deadlines.

Cognitive effort. For the purposes of this AR study, evidence for cognitive engagement was approximated by my observations, such as when students would ask a series of questions while trying to puzzle a conclusion. Cognitive engagement sometimes could be triangulated by student self-reports of how hard they were thinking.

Constructive dialogue occurred nearly constantly as students worked together. Interestingly, although students could freely find me anywhere in the room to ask me questions at any time, my arrival at a table would precipitate a flurry of questions from the group in question. If I observed from a distance, then students would ask each other the questions more frequently than they would come find me to ask.

Usually when students asked me questions, they already knew the answer. I did not understand at first why students were doing this. I finally asked Sabryna, a foreign student with teacher education training, why she kept asking me questions when she always knows the right answer. She laughed at me that they had been discussing it at her table but wanted me to "judge" the right answer. Students were therefore evincing a significant degree of cognitive engagement but needed consistent and persistent feedback to build confidence and to check that they were learning the correct things.

Students often and frequently tied material in class to outside knowledge, possibly demonstrating perezhivanie as described by Vygotsky (Hodges, 2018). For example, in the respiration lab (week 12) introduction, I joke with students, "we used to do this lab on goldfish but too many of them died, so now we use college students." Multiple groups on different days tried to imagine how to do the laboratory on goldfish, which led to other conversations about aquariums and cats. In the osmosis lab, one group discussed what their skin feels like after swimming in the ocean compared to taking a bath.

In one case, I misunderstood a student's question but the student remained cognitively engaged. I generally refuse to answer questions that students will be able to answer once they have experimental results as I want students to draw their own conclusions instead of looking for what they think will be the right answer. During the osmosis lab, Dylan asked me if sugar would get wet. I thought he meant the sugar in the experiment, and it will, but I know from experience that it is usually more fun for students if they're surprised. For this reason, I told him to wait and see and, "No spoilers!" A few minutes later, he clarified, "If you leave sugar out on the countertop, will it get wet?" Sabryna listening from the table behind him. She is from a humid country famous for sugar production and I suspected that she bakes, so I asked her to answer the question. She was pleased to talk about the difficulties of sugar in her home country, and Dylan, who may never have left this city, was interested to learn something new.

Students exhibited a high degree of cognitive engagement consistently regardless of laboratory protocol.

Behavior, emotion, and cognitive findings between standard and jigsaw weeks. In general, students were highly engaged as demonstrated by observations on their behavior, emotion, and cognitive effort during standard and jigsaw weeks. However, negative engagement indicators occurred more frequently during jigsaw weeks. Students during jigsaw weeks exhibited more periods of idleness, expressed more feelings of frustration and boredom, and indicated that they were confused more often than in standard weeks. Given the high degree of engagement expressed during standard weeks, it would have been difficult to improve engagement.

An unexpected problem was that jigsaw weeks exposed student to more embarrassment. In the jigsaw week for one section, Zeniah, an older black woman, was assigned the role of reader. When she began reading her section aloud, it became quickly apparent that her reading skills are very poor. Emily, a more privileged and younger white woman, caught my eye during the reading, flicked her eyes to Zeniah, back to me, and smiled. I do not think she was mocking Zeniah, as she is generally a kind, patient, and supportive lab partner, but I think she was indicating the awkwardness of the situation. Later, when Zeniah and Emily's group found they had made a mistake and I asked them to double check what had happened, Zeniah handed the paper to Emily and said, "You check it."

In another section, Makin, the Middle Eastern man in his late 30's, was having difficulty working with the younger white women at his table. He was assigned the assembler job and completed it very quickly without explaining to his partners what he was doing. When he made a mistake, his partners were not as patient or kind as they could have been. The awkwardness in this situation did not help the group dynamics, which ultimately caused Makin to request a transfer to a different section of my class. This was observed by a later focus group when students from a different lab table questioned what they thought his odd behavior.

Ultimately, the student engagement was so high in the standard weeks, the jigsaw weeks did not improve student engagement in ways that were observable by the professor-researcher or through spontaneous and semi-structured interviews. Students were cognitively engaged in all weeks but emotional and behavioral findings were better in standard weeks. Jigsaw weeks opened up students to frustration and embarrassment. By this point in the experiment, I was fairly sure that jigsaw protocols were not worth the time investment necessary to convert our existing protocols but I was left with two new questions, following the emergent design of qualitative action research (Creswell & Creswell, 2017; Mertler, 2013). As I scheduled focus groups, my two overarching questions were:

1) Do students agree with my interpretations of our findings?
2) What do students think would improve their success (learning, persistence, and completion, or as otherwise defined by them) in this laboratory?

Focus group findings. All participating students were invited to focus groups. All three focus groups were recorded, transcribed, and coded. Students were questioned about interpretations of events I had witnessed in the previous three weeks and probed for opinions to improve the course.

Students generally supported my interpretations of events. They felt so strongly about how to improve the course, they volunteered comparisons to lecture and opinions about the jigsaw laboratory without prompting. Students identified several factors as important to their learning, including what they call "hands-on" activities, (Sherry said "If I can touch it, I'm good,") the importance of dialogue and group support, a desire for more meaningful feedback, and a deep desire for more opportunities to demonstrate knowledge, track their own progress, and develop competence in learning.

When questioned, students felt that lab was as good as it was but student engagement and success could be improved by targeting lecture. In one group, I began focus groups by asking "How do you feel about lab?" A student immediately responded, "I like it way better than lecture." This theme was continued across focus groups until Sabryna said, "Miss White, just be yourself."

In support of emotional engagement, students identified that they were happy in lab because they enjoyed working with each other and cared about each other as people. This confirmed what I had suspected in my field notes regarding how laughter and care for each other seemed to aid learning. Students specifically referenced that they liked explaining and being explained to as anticipated by Vygotsky (1978), Palincsar (1998), and Doolittle (Doolittle, 2014). Lynn, a Latina woman expressed, "…getting the perspective from your peers compared to like a teacher who has the biology degree

…when you talk to your peers about it, they have the same questions you do. So you guys … learn together."

Students demonstrated behavioral engagement as they spoke to their efforts to ensure everyone played a part. Deandre, a young black southern man, and Augusta, a young black African woman, were lab partners with Fallon, a white woman returning to community college from a four-year school, and Moshe, a member of a conservative religious group. Despite their differences, as I watched them in my professorial role over the entire semester, I had considered that they worked exceedingly well together. Deandre described why this was as follows:

> You come to realize what everyone's strengths and weaknesses are. Like Augusta, she's a fast writer, so she would write out the answers, and I may be like, I processed it quicker and I'd be, 'hey can you write that down', and now she's doing that. [Fallon] works faster so she'll probably assemble all the equipment and Moshe's just timing so it all depends on what everyone's strong points are.

Key to this statement is the acknowledgement by Augusta and Deandre that Moshe sometimes struggled to understand laboratory expectations as he had not taken science classes in high school, but Fallon worked very quickly due to her extra experience of two years of college. This group had found a way to include everyone, even if Moshe's only job was to keep the timing on the experiments. Moshe eventually withdrew from the course but spoke to me in a semi-structured interview about how important the group had been to keeping him in the class as long as he did.

In the collection of the field notes, I had been surprised to see so much cell phone usage and was not sure whether off-topic use should be considered a sign of behavioral disengagement. I asked all three focus groups how they interpret cell phones. Student-participants in all three groups rushed to defend their personal use as including timing experiments, googling answers, or checking the online textbook, which would be positive behavioral engagement. I then asked about the music videos, social media, and text messaging witnessed in the data collection weeks. Students uniformly believed that such cell phone use was disrespectful and a behavioral sign of cognitive disengagement. Some students questioned why a student would come to class and be disrespectful, as in the case of a student who told me, "You should have called them out then. Oh, excuse me sir, I know you're paying to be here but uh, this class is not supposed to be recorded like that."

Students felt that kindness and group member support indicated positive emotional engagement but frustration and rudeness were signs of negative emotional engagement. Summer said, "you can't learn if you're frustrated, your brain doesn't work."

Ultimately, students consider their overall engagement in laboratory to be high and strongly preferred standard weeks to jigsaw weeks. In one focus group, students began volunteering opinions about how much they hated the jigsaw week before I even mentioned it. This was particularly interesting given that for these students it had been a full month since they had been exposed to the treatment. Leila told me, "I did not like when one person read, one person did the experiment." Tommie made a noise of disgust and then another student said, "That was just chaos! … I like when everybody helps each other." Some students tried to find ways to change the jigsaw labs so that they would work better but there was no consensus as to what changes should be implemented because students fundamentally did not want to be directed in how to split tasks.

Thursday's students were the only section that rated the jigsaw lab higher on the modified ASPECT survey. The Thursday students attending the focus groups were not sure why that might be. They suggested that it might be because it was interactive, but Deandre suggested, "we still enjoy each other's company, so we probably would have still enjoyed it no matter what it was." I tried to explore this idea as follows:

Me: I could just hand you a paper bag and leave for two hours, and you'd still get something meaningful?

(laughing)

Augusta: Yes! yes! It would.

Deandre: Yes, probably, because I'm pretty sure you'd come back and we're sitting here debating about it and everything.

Sabryna: In our group we'd be like, "and this is not wrong and this is wrong and, (calling voice) Miss White, please come here or something!" (they're laughing)

I asked these students why they felt they would be able to start having meaningful discussions. Deandre answered,

> I think it was because our initial first day, you broke the ice with the whole class showing that it's ok to express how you feel and be comfortable in

> the classroom environment because I think the output of classes really start from the teacher.

From this, Deandre demonstrated the importance of emotional engagement as well as the role of the instructor in establishing an environment where student engagement can flourish (Kuh, 2009; Wolf-Wendel et al., 2009).

Conclusion

In the interest of increasing student engagement in the beginning biology laboratory, students were exposed to jigsaw protocols and evaluated for signs of behavioral, cognitive, and emotional engagement through a modified ASPECT survey, observations, interviews, and focus groups. Results indicated that student engagement across all three domains was generally higher in standard weeks compared to jigsaw weeks. Through focus groups and interviews, students demonstrated understanding of engagement to be a dance between their own attitude but also the attitudes and curricular decisions of their faculty, concurring with the student engagement conclusions of Kuh (2009) and Wolf-Wendel, Ward, and Kinzie (2009). Students provided many suggestions for improvement which will be further discussed in Chapter Five of this DiP. A summary of the study, a further discussion of the major points of the study, and a detailed description of the action research plan developed with student-participants will be also be discussed along with reflections on methodology, suggestions for how this study could have been improved, and potential avenues for further research.

Chapter 5 Discussion and Action Plan

In this chapter, an overview of this Action Research study including the problem of practice, research question, and purpose is described. The findings are interpreted and reflected upon within the context of the guiding literature. An action plan is proposed and recommendations are identified.

Overview of the Study

At NCC, 38% of students enrolled in beginning biology do not earn a C or better. Student engagement is thought to be a factor in student success, as described in Chapter Two of this DiP. CCSSE active and collaborative learning scores from NCC are lower than benchmark institutions. It is possible that student engagement can be improved through the use of jigsaw techniques as described in Chapter Two of this DiP. The purpose of this action research study was to investigate the impact of a jigsaw method on student engagement in the beginning biology laboratory through student self-perceptions on a modified ASPECT survey, student observations, spontaneous and semi-structured interviews, and focus groups. Specifically, I asked "what is the impact of jigsaw methods on student engagement in the beginning biology protocol?" The findings of this study were used to design an action plan with student-participants as described in this chapter.

Action research can be conceptualized as a spiral where an educator looks, acts, and looks again (Mertler, 2013). I have been around this spiral for many years in my attempts to improve this course as described in Chapter One of this DiP. During this loop of the spiral, I asked students to complete modified ASPECT surveys about their perceived engagement after three weeks during which they were asked to complete our standard laboratory protocol or a jigsaw laboratory protocol designed for the purposes of this study. In each week, I used a behavioral checklist and made field notes observing students as they worked. Spontaneous interviews were conducted during laboratory sessions when it would not interfere with student learning. After lab each week, a few students were asked to participate in semi-structured interviews. After the three laboratory weeks of data collection, self-selected student-participants attended focus groups to share their perceptions, discuss the professor-researcher's findings, and construct an action plan.

Interpretation of Findings

More detailed findings are described in Chapter Four of this DiP. Here, findings are reviewed to inform the following discussion and interpreted within the context of the guiding literature.

Summary of the findings. Modified ASPECT survey results indicated students were more engaged during most standard weeks than jigsaw weeks, confirmed by student comments in interviews and focus groups. Week 12, the respiration lab, was an outlier possibly because the laboratory material is intrinsically more interesting to students in that week. The behavioral checklist was not a useful way to examine student engagement, but field notes were a useful source of direct behavioral engagement observations and indirect emotional and cognitive engagement observations. Findings regarding all three forms of engagement were qualitatively triangulated through spontaneous and semi-structured interviews and focus groups.

Constructivism and this AR study. Constructivism as described in Chapters One and Two of this dissertation formed the underlying theoretical framework for this entire AR study, including both decisions made regarding the jigsaw intervention and also how student data was interpreted. Constructivism appeared repeatedly throughout the data collection stage of this DiP especially in the form of constructive dialogue and social interactions as described by Vygotsky (1978). When laboratory observations were coded, it became apparent that constructive dialogue was one of the two major activities in which student-participants engaged. Constructive dialogue manifested as frequent conversations between students or between students and the professor, in which learning was vocalized, checked, transformed, and integrated with existing knowledge in the ways anticipated by Doolittle (2014).

The importance of constructive dialogue to interpret the laboratory experience was reiterated by students during post-lab semi-structured interviews and focus groups when they volunteered that the discussions helped them learn. Deandre described how his learning surprised him more in laboratory compared to lecture when he said, "when you're being interactive, you're like, wait, did I really just say ALL that?" Later he said,

> Someone might ask a question … you didn't know the answer and you all just put your heads together to answer that question, you also learn from the question, he asks what your brain never even wouldn't think. That was the good of having the groups.

Perhaps most poignantly, during a post-lab semi-structured interview Moshe described the group work as essential to his learning and one of the things that could have helped him stay in the class had he recognized that sooner in the semester. Prior to the data collection stage of this DiP, I had wondered if fostering social interactions would improve student engagement and success and, given the degree to which students reported this as essential to their learning, it probably would. In future courses, I will seek to build these social interactions more rapidly and more mindfully.

Active, collaborative, and cooperative learning and this AR study. Active, collaborative, and cooperative learning were identified as operational forms of constructivist theory in Chapters One and Two of this DiP. Machemar and Crawford (2007) warned that it is challenging to create active learning activities. I found creating jigsaw laboratories was an onerous process and, in one week, I made so many mistakes, students could barely finish the laboratory protocol. Although it is possible I improved by the time I wrote the third laboratory protocol in jigsaw style, I ultimately considered the apparent loss of student engagement and difficulty in creating jigsaw protocols not to be worth my time and effort.

Machemar and Crawford (2007) also criticized active learning for taking time away from lecture that could be used to cover more material, which was not a serious problem in this case as our standard laboratory protocols were already active. However, the jigsaw protocols did seem to take a little longer to complete and students didn't engage in constructive dialogue as often to justify this increased time. Although Machemar and Crawford were comparing active learning to passive lectures, in the case of this PoP, the use of jigsaw learning laboratory protocols did not appear to be a more efficient use of time for learning compared to our standard protocols.

One major difference from Machemar and Crawford's (2007) findings was that my student-participants deeply valued collaborative learning, defined by Bruffee (1995) as students working together on cognitively complex and authentic tasks. Prince (2004) criticized much of the literature on active learning as failing to clearly define the constructs, as Machemar and Crawford failed to do. Prince was used to justify the pilot study of this intervention rather than a full roll-out because effect sizes tend to be small compared to the input of instructor time. Given that writing the jigsaw laboratory protocols was so time-consuming, given that students did not demonstrate effect gains, and given that my student-participants clearly identified collaboration as important to their learning, it will be better to improve student learning via other collaborative techniques rather than trying to improve upon an already adequate laboratory protocol through jigsaw methodology.

Herrmann (2013) and Machemar and Crawford (2007) both wrote that regardless of classification, any learning technique used in colleges must be tightly linked to expected outcomes and assessibility for student buy-in. This was indirectly supported by student reports in focus groups when student-participants argued they liked laboratory better than lecture because there were more opportunities to demonstrate their learning in laboratory, and because they could clearly see linkages between activities and exams. Several students said indicated that assessment could be as low-stakes as when I used gold star stickers but that it essential for their learning to understand how information flowed through lecture and laboratory from activities to exams.

Student engagement and this AR study. As reviewed in Chapter Two of this DiP, student engagement is tightly linked to a variety of positive student outcomes. This body of research was supported by the findings of this AR study. I observed and student-participants confirmed that when they exhibited disengaged behaviors such as playing with cell phones or snapping at each other, learning was not happening. Alternately, we agreed that when they were engaged (and in some cases, students volunteered this word without prompting), they learned more. Although I could not meaningfully link grades to engagement scores on the modified ASPECT survey due to the short data collection period and an agreement with NCC IRB, student self-reports were that they felt they learned more in the weeks the modified ASPECT survey results indicated more engagement. As such, student engagement at NCC cannot be disconfirmed as an important ingredient in student success.

Jigsaw methods and this AR study. Although research reviewed in Chapter Two revealed mixed results regarding the efficacy of jigsaw techniques in college and biology courses, the findings of this AR study were clear that jigsaw protocols were not effective for improving student engagement in the beginning biology laboratory at the largest and most urban campus of NCC. Eddy, Brownell, Thummaphan, Lan, and Wenderoth (2015) suggested jigsaw methods may reduce bias in peer discussion groups but this did not appear in this AR study. In one case, forcing an educationally-disadvantaged woman to read out loud revealed significant and previously-hidden-to-me gaps in reading ability, something observed by a more educationally-advantaged student in the group. In another case, when one laboratory group began comparing air quality by neighborhood, it became apparent to the professor-researcher and several black students that air quality rates also intersected racial diversity rates – but no white students appeared to notice this disparity. If anything, jigsaw methods brought bias to the forefront in a way that was uncomfortable but, due to the nature of a biology laboratory, not easily discussed. These could have been excellent learning opportunities in a classroom environment where deviations from course plans are more tolerated and this discomfort may have been the intent of the original design to reduce prejudice (Williams, 2004) but when we must stick to a schedule across a thousand students and ostensibly focus on science, these disparities just caused students to feel bad and may have negatively impacted engagement.

Implications of this Action Research Study

Students at NCC nearly uniformly hated the jigsaw protocols, a loathing that came through even as they attempted to soften their statements with suggestions on how they could be improved. There was no consensus on how the jigsaw protocols could be improved as students fundamentally hated being split up as they worked, something that is essential to the technique (Griffin & Howard, 2017).

Two students did indicate that if this had just been the way the course had been run from the beginning of the semester, they would have adapted and made it work. It is my professional judgment that given our standard protocol is generally liked (at least by students who persisted past midterm without withdrawing), given how challenging it was for me to write effective jigsaw protocols, and given the high importance of constructive dialogue found by this study, beginning biology students at NCC would be happier, engaged more, and learn more with our standard protocols instead of jigsaw protocols.

Practitioners interested in jigsaw techniques must first consider their student population and personal teaching style. As Deandre described, my teaching style was to "break the ice" and encourage group work from the beginning of the semester. Many students developed a sense of community and were more interested in belonging to bigger groups than they were in developing individual task mastery. Other practitioners may instead value personal mastery over group identity and could find this technique to work better in their classrooms.

Researchers should be warned of the challenges intrinsic in assessing student engagement and always use multiple instruments. Although I thought a behavioral checklist would allow me to quickly identify student engagement, in reality it did not yield any useful data for the reasons described in Chapter Four of this DiP. Had I relied on the modified ASPECT survey alone I would have missed the tremendous nuance my students shared in interviews and focus groups. At no point could I objectively measure student engagement, as all my measures are fundamentally subjective. The only ways in which rigor and validity could be ensured for this study was the use of multiple engagement measures and frequent conversations with students and pertinent co-workers about what I thought the findings might be.

Action Plan and Suggestions for Future Research and Practice

This action research study was undertaken in the interest of determining whether or not the use of a jigsaw protocol in the beginning biology laboratory would improve student engagement. Had students demonstrated gains in engagement I would have implemented an action plan to rewrite our existing laboratory manual to use this technique frequently. Student engagement gains were not demonstrated and student comments were clear that jigsaw techniques were not as effective as our existing laboratory protocols for encouraging student engagement. However, this does not solve our original problem that student success rates in beginning biology at NCC could be improved.

Student reports triangulated with my observations of their interactions caused me to conclude that constructivism should continue to inform the ways in which I approach curriculum design. Although I had previously noticed how often students talk to each other when learning, I had not previously understood how critical these interactions are to learning. In future classes, I will seek to embed activities that encourage student interaction from day one through an entire semester, and I will also explain the logic to students. Furthermore, given the experiences reported by Deandre and Moshe, deliberate incorporation of more constructivist techniques may improve social and racial inequities in the beginning biology laboratory.

Students uniformly reported that they liked the standard laboratory curriculum but the impediments to their success came from the gap between laboratory and lecture which at this campus of NCC is often taught by two different non-communicating professors. Students frequently spoke as to how they felt we needed to either communicate better or link the courses. The first part of our action plan is therefore that I will work with my coworkers to link laboratory and lecture such that both halves will be taught by the same professor with the same cohort of students.

A frequent student comment from focus groups indicated that students needed frequent opportunities to demonstrate their learning. Coupled with the issues we have of faculty turnover and the high degree of new contingent faculty, we may have quality control and consistency problems across sections of this course. Along with linking laboratory and lecture, the second part of our action plan is that I will conscientiously implement structures for improving faculty development through discussion opportunities with part-time faculty.

Following guidance from students in the focus groups and my own unanswered questions, in future research, I would like to investigate two questions. What are the ways that collaborative and constructive learning relationships between students can be built as early as the first week of a semester? Additionally, it seems that instructor quality significantly varies at NCC, especially when new contingent faculty are hired to teach this course. What are the experiences of new faculty at NCC, and what are the most effective practices that we can implement to help them grow rapidly and support them as they meet our student needs?

Description of the Action Researcher as Curriculum Leader

At the end of this spiral of action research, I find that I am and am not in the same place I started. I have not improved student outcomes but I have learned that changing curriculum in the written laboratory protocols will probably not be as effective as changing other factors related to the course. To this end, I have begun working with the department head to combine laboratory and lecture sections. The problem is that it is now much more challenging to cobble together a full-time teaching schedule, as the laboratory times block the lecture times. Furthermore, as a response to other work I completed during this time period, I have been promoted to a special project that further reduces my available time for teaching. Although I began this study thinking that I could rewrite the laboratory book and improve learning for half the students at NCC (all those who take this course), I now find that it is not the most effective way to improve student outcomes.

Although my classroom time may decrease, my special project places me in a better position to teach, advise, and lead the entire faculty body into an evidence-based decision-making model. I am using what I learned from this project, as well as from my other experiences at USC, to develop an entirely new assessment and learning framework that will apply to all 1,300 faculty and all students at NCC. Finding that curriculum changes don't matter as much as relationships between faculty and students, or between students and other students, or as much as the quality of the faculty is incorporated into all the work I do for the college.

Limitations of this Action Research Study

An important component of an action research study is that it be feasible within the constraints and sphere of influence of the professor-researcher (Mertler, 2013). The constraints of this study were myriad and probably influenced the results.

In the summer prior to the data collection period, NCC created a new Institutional Review Board (IRB). This administrative change delayed the necessary permission from NCC to conduct this study such that I was not able to collect data until after midterm. Although I was still able to collect meaningful, interesting, and actionable data, my students had already bonded into solid friendships by this point in the semester and I lost the ability to determine whether or not jigsaw activities are impactful at the beginning of a semester before students make friends.

A second problem with collecting data after midterm was that many students had already withdrawn from the course, already self-selecting out of the study before they ever saw the first jigsaw protocol. This study was therefore unable to collect information about the most at-risk students by virtue of their disappearance from the course.

A third problem with this study included the requirement by NCC that students opt in with consent letters. Findings as described in this DiP therefore only refer to the subset of a convenience sample that chose to opt in and therefore may not apply to all student experiences.

A fourth potential limitation of this AR study may be that I am not experienced at writing jigsaw laboratory protocols. I attempted to write using best practices as described by the literature reviewed in Chapter Two of this DiP, but it is possible that a more talented writer would demonstrate better student engagement.

A final factor that may have impacted student engagement was that my department underwent several upheavals during this semester including a lack of faculty for some sections, the death of a faculty member, and a particularly upsetting mass shooting event in ML city. These may or may not have impacted results, given that any semester will have upheavals.

Conclusion

This action research study was originally undertaken in order to better understand the factors influencing student engagement as proxy for student success and retention in the beginning biology laboratory at NCC. Constructivist theory guided the selection of jigsaw methodology as a potential intervention to improve student engagement. Student engagement was assessed via modified ASPECT survey, field observations, spontaneous and semi-structured interviews, and focus groups. Student engagement worsened in jigsaw weeks compared to standard weeks. Through student comments, I learned that our curriculum is adequate but there are still several things we can do to improve student engagement, learning, and success. These items include better linking of our laboratory and lecture sections as well as ensuring all faculty receive adequate training and professional development to become excellent educators. As my co-faculty and I continue to work to improve curriculum, we are now positioned to focus our efforts in productive directions.

References

Altmann, J. (1974). Observational study of behavior: sampling methods. *Behaviour*, *49*(3), 227–266.

Amedu, O. I. (2015). The effect of gender on the achievement of students in biology using the jigsaw method. *Journal of Education and Practice*, *6*(17), 176–179.

Anthony, G. (1996). Active learning in a constructivist framework. *Educational Studies in Mathematics*, *31*(4), 349–369.

Appleton, J. J., Christenson, S. L., & Furlong, M. J. (2008). Student engagement with school: Critical conceptual and methodological issues of the construct. *Psychology in the Schools*, *45*(5), 369–386.

Axelson, R. D., & Flick, A. (2010). Defining student engagement. *Change: The Magazine of Higher Learning*, *43*(1), 38–43.

Bass, C. (2012). Learning theories & their application to science instruction for adults. *American Biology Teacher*, *74*(6), 387–390.

Bazzul, J. (2015). Tracing “ethical subjectivities” in science education: how biology textbooks can frame ethico-political choices for students. *Research in Science Education*, *45*(1), 23–40.

Bratt, C. (2008). The jigsaw classroom under test: No effect on intergroup relations evident. *Journal of Community & Applied Social Psychology*, *18*(5), 403–419.

Bruffee, K. A. (1995). Sharing our toys. *Change*, *27*(1), 12.

CCCSE - Initiative on Student Success - Student Quotes. (n.d.). Retrieved September 16, 2018, from http://www.ccsse.org/center/initiatives/iss/quotes_actcolllearning.cfm

CCSSE - About CCSSE. (n.d.). Retrieved September 10, 2018, from http://www.ccsse.org/aboutccsse/aboutccsse.cfm

Chi, M., Adams, J., Bogusch, E. B., Bruchok, C., Kang, S., Lancaster, M., … Yaghmourian, D. L. (2018). Translating the ICAP theory of cognitive engagement into practice. *Cognitive Science*, *42*(6), 1777–1832.

Chi, M., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist*, *49*(4), 219–243.

Colosi, J. C., & Zales, C. R. (1998). Jigsaw cooperative learning improves biology lab courses. *BioScience*, *48*(2), 118–124.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Crone, T. S., & Portillo, M. C. (2013). Jigsaw variations and attitudes about learning and the self in cognitive psychology. *Teaching of Psychology*, *40*(3), 246–251.

Dana, N. F., & Yendol-Hoppey, D. (2014). *The reflective educator's guide to classroom research: learning to teach and teaching to learn through practitioner inquiry*. Corwin Press.

Deutsch, M. (1949). A theory of co-operation and competition. *Human Relations*, *2*(2), 129–152.

Dewey, J. (1998). *Experience and education, 60th anniversary edition*. Kappa Delta Pi.

Doolittle, P. E. (2014). Complex constructivism: A theoretical model of complexity and cognition. *International Journal of Teaching and Learning in Higher Education*, *26*(3), 485–498.

Eddy, S. L., Brownell, S. E., Thummaphan, P., Lan, M.-C., & Wenderoth, M. P. (2015). Caution, student experience may vary: Social identities impact a student's experience in peer discussions. *CBE-Life Sciences Education*, *14*(4), ar45.

Ertmer, P. A., & Newby, T. J. (1993). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly*, *6*(4), 50–72.

Faust, J. L., & Paulson, D. R. (1998). Active learning in the college classroom. *Journal on Excellence in College Teaching*, *9*(2), 3–24.

Fosnot, C. T., & Perry, R. S. (1996). Constructivism: A psychological theory of learning. *Constructivism: Theory, Perspectives, and Practice*, *2*, 8–33.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*(1), 59–109.

Fredricks, J. A., & McColskey, W. (2012). The measurement of student engagement: A comparative analysis of various methods and student self-report instruments. In *Handbook of research on student engagement* (pp. 763–782). Springer.

Galletta, A. (2013). *Mastering the semi-structured interview and beyond: From research design to analysis and publication*. NYU press.

Gasiewski, J. A., Eagan, M. K., Garcia, G. A., Hurtado, S., & Chang, M. J. (2012). From gatekeeping to engagement: A multicontextual, mixed method study of student academic engagement in introductory STEM courses. *Research in Higher Education*, *53*(2), 229–261.

Griffin, C. P., & Howard, S. (2017). Restructuring the college classroom: A critical reflection on the use of collaborative strategies to target student engagement in higher education. *Psychology Learning & Teaching*, *16*(3), 375–392.

Handelsman, M. M., Briggs, W. L., Sullivan, N., & Towler, A. (2005). A measure of college student course engagement. *The Journal of Educational Research*, *98*(3), 184–192.

Henrie, C., Halverson, L., & Graham, C. (2015). Measuring student engagement in technology-mediated learning: A review. *Computers & Education*, *90*, 36–53.

Herrmann, K. J. (2013). The impact of cooperative learning on student engagement: Results from an intervention. *Active Learning in Higher Education*, *14*(3), 175–187.

Hodges, L. C. (2018). Contemporary issues in group learning in undergraduate science classrooms: A perspective from student engagement. *CBE—Life Sciences Education*, *17*(2), es3.

Jacobs, G. M. (2015). Collaborative learning or cooperative learning? The name Is not important; flexibility is. *Online Submission*, *3*(1), 32–52.

Johnson, D., & Johnson, R. (1999). Making Cooperative Learning Work. *Theory into Practice*, *38*(2), 67–73.

Johnson, D., & Johnson, R. (n.d.). What is cooperative learning?: An overview of cooperative leraning. Retrieved September 16, 2018, from Cooperative Learning Institute website: http://www.co-operation.org/what-is-cooperative-learning/

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, *33*(7), 14–26.

Kahu, E. (2013). Framing student engagement in higher education. *Studies in Higher Education*, *38*(5), 758–773.

Kahu, E., & Nelson, K. (2018). Student engagement in the educational interface: understanding the mechanisms of student success. *Higher Education Research & Development*, *37*(1), 58–71.

Kuh, G. D. (2009). What student affairs professionals need to know about student engagement. *Journal of College Student Development*, *50*(6), 683–706.

Lederman, N. G., & Lederman, J. S. (2015). What Is a theoretical framework? A practical answer. *Journal of Science Teacher Education*, *26*(7), 593–597. https://doi.org/10.1007/s10972-015-9443-2

Lei, S. A., Kuestermeyer, B. N., & Westmeyer, K. A. (2010). Group composition affecting student interaction and achievement: instructors' perspectives. *Journal of Instructional Psychology*, *37*(4), 317–326.

Leyva-Moral, J., & Riu Camps, M. (2016). Teaching research methods in nursing using Aronson's Jigsaw Technique. A cross-sectional survey of student satisfaction. *Nurse Education Today*, *40*, 78–83.

Lord, T. R. (2001). 101 reasons for using cooperative learning in biology teaching. *The American Biology Teacher*, *63*(1), 30–38.

Machemer, P., & Crawford, P. (2007). Student perceptions of active learning in a large cross-disciplinary classroom. *Active Learning in Higher Education*, *8*(1), 9–30.

Machi, L. A., & McEvoy, B. T. (2016). *The literature review: Six steps to success*. Corwin Press.

Mahn, H., & John-Steiner, V. (2002). The gift of confidence: A Vygotskian view of emotions. *Learning for Life in the 21st Century: Sociocultural Perspectives on the Future of Education*, 46–58.

Massey, O. T. (2011). A proposed model for the analysis and interpretation of focus groups in evaluation research. *Evaluation and Program Planning*, *34*(1), 21–28.

McClenney, K., Marti, C. N., & Adkins, C. (2012). Student Engagement and Student Outcomes: Key Findings from "CCSSE" Validation Research. *Community College Survey of Student Engagement*.

McCormick, A. C., & McClenney, K. (2012). Will these trees ever bear fruit?: A response to the special issue on student engagement. *The Review of Higher Education*, *35*(2), 307–333.

Mehta, S., & Kulshrestha, A. K. (2014). Implementation of cooperative learning in science: A developmental-cum-experimental study. *Education Research International*, 1–7.

Menekse, M., Stump, G. S., Krause, S., & Chi, M. T. (2013). Differentiated overt learning activities for effective instruction in engineering classrooms. *Journal of Engineering Education*, *102*(3), 346–374.

Mertler, C. A. (2013). *Action research: Improving schools and empowering educators* (4 edition). Los Angeles: SAGE Publications, Inc.

Nolen, A. L., & Putten, J. V. (2007). Action research in education: Addressing gaps in ethical principles and practices. *Educational Researcher*, *36*(7), 401–407.

NSSE Engagement Indicators. (n.d.). Retrieved September 10, 2018, from http://nsse.indiana.edu/html/engagement_indicators.cfm

NSSE survey_development. (n.d.). Retrieved September 10, 2018, from http://nsse.indiana.edu/html/survey_development.cfm

Orenturk, B., Goktas, Y., & Bulu, S. T. (2004). What construct constructivism: Moving from the theory to application. *Information Technology Based Higher Education and Training, 2004. ITHET 2004. Proceedings of the FIfth International Conference On*, 342–347. IEEE.

Ortlipp, M. (2008). Keeping and using reflective journals in the qualitative research process. *The Qualitative Report*, *13*(4), 695–705.

Palincsar, A. S. (1998). Social constructivist perspectives on teaching and learning. *Annual Review of Psychology*, *49*(1), 345.

Panitz, T. (1999). *Collaborative versus cooperative learning: A comparison of the two concepts which will help us understand the underlying nature of interactive learning.* Retrieved from eric. (For full text: http://www.capecod.net/~TPanitz/Tedspage.)

Peterson, S. E., & Miller, J. A. (2004). Comparing the quality of students' experiences during cooperative learning and large-group instruction. *Journal of Educational Research*, *97*(3), 123–133.

Pike, G. R. (2013). NSSE benchmarks and institutional outcomes: A note on the importance of considering the intended uses of a measure in validity studies. *Research in Higher Education*, *54*(2), 149–170.

Poggenpoel, M., & Myburgh, C. (2003). The researcher as research instrument in educational research: A possible threat to trustworthiness? (a: research_instrument). *Education*, *124*(2), 418.

Popkewitz, T. S. (1998). Dewey, Vygotsky, and the social administration of the individual: Constructivist pedagogy as systems of ideas in historical spaces. *American Educational Research Journal*, *35*(4), 535–570. https://doi.org/10.3102/00028312035004535

Price, D., & Tovar, E. (2014). Student engagement and institutional graduation rates: Identifying high-impact educational practices for community colleges. *Community College Journal of Research and Practice*, *38*(9), 766–782.

Price, D. V., & Tovar, E. (2014). Student engagement and institutional graduation rates: Identifying high-impact educational practices for community colleges. *Community College Journal of Research and Practice*, *38*(9), 766–782.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*(3), 223–231.

Reeve, J., & Lee, W. (2014). Students' classroom engagement produces longitudinal changes in classroom motivation. *Journal of Educational Psychology*, *106*(2), 527.

Ritchie, J., Lewis, J., Nicholls, C. M., & Ormston, R. (2013). *Qualitative research practice: A guide for social science students and researchers*. Sage.

Rossman, G. B., & Rallis, S. F. (2003). *Learning in the field: An introduction to qualitative research*. SAGE.

Roulston, K. (2010). Considering quality in qualitative interviewing. *Qualitative Research*, *10*(2), 199–228.

Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). Los Angeles: Sage.

Schiro, M. S. (2013). *Curriculum theory: Conflicting visions and enduring concerns*. Sage Publications.

Senge, P. M., Cambron-McCabe, N., Lucas, T., Smith, B., & Dutton, J. (2012). *Schools that learn (updated and revised): A fifth discipline fieldbook for educators, parents, and everyone who cares about education*. Crown Business.

Sinatra, G. M. ., Heddy, B. C. ., & Lombardi, D. (2015). The challenges of defining and measuring student engagement in science. *Educational Psychologist*, *50*(1), 1–13.

Sjøberg, S. (2007). Constructivism and learning. *International Encyclopaedia of Education*, *3*.

Slish, D. F. (2005). Assessment of the use of the jigsaw method and active learning in non-majors, introductory biology. *Bioscene: Journal of College Biology Teaching*, *31*(4), 4–10. (Association of College and Biology Educators. Web site: http://acube.org).

Theobald, E. J., Eddy, S. L., Grunspan, D. Z., Wiggins, B. L., & Crowe, A. J. (2017). Student perception of group dynamics predicts individual performance: Comfort and equity matter. *PloS One*, *12*(7), e0181336.

Vygotsky, L. S. (1978). *Mind in society: The development of higher mental process*. Cambridge, MA: Harvard University Press.

Wiggins, B. L., Eddy, S. L., Grunspan, D. Z., & Crowe, A. J. (2017). The ICAP active learning framework predicts the learning gains observed in intensely active classroom experiences. *AERA Open*, *3*(2), 2332858417708567.

Wiggins, B. L., Eddy, S. L., Wener-Fligner, L., Freisem, K., Grunspan, D. Z., Theobald, E. J., … Crowe, A. J. (2017). ASPECT: A survey to assess student perspective of engagement in an active-learning classroom. *CBE—Life Sciences Education*, *16*(2), ar32.

Williams, D. (2004). Improving race relations in higher education: The jigsaw classroom as a missing piece to the puzzle. *Urban Education*, *39*(3), 316–344.

Wolf-Wendel, L., Ward, K., & Kinzie, J. (2009). A tangled web of terms: The overlap and unique contribution of involvement, engagement, and integration to understanding college student success. *Journal of College Student Development*, *50*(4), 407–428.

Appendix A: Student Consent Letter

Dear Student,

In this course, you have an opportunity to assist me in studying teaching methodology. I am conducting a study as part of my dissertation looking into the engagement of students enrolled at community colleges. Would you be willing to participate in a research study to improve student learning in the laboratory?

Participation involves completing laboratory activities with your lab group, answering questions and a questionnaire, and, if willing, attending a focus group to discuss findings and make a plan to improve the laboratory experience. Your participation is very valuable to the development of this study and will lend valuable data to the ongoing development of teaching methods at [NCC]. I strongly encourage you to take advantage of this opportunity to gain the experience that comes with participation, but your participation is not mandatory.

Please be aware that participation in the study does not count for extra credit, and your grade will not be penalized if you decline to participate. Your privacy will be protected and your feedback will remain anonymous. You will not be identified and associated with the data you provide by participating.

Sincerely,

Professor Kalina White

I understand and agree to participate in this research study.

________________________ _______________ ________________________________

Signature Date Printed Name

Appendix B: Data Collection Schedule

Week beginning	NCC Laboratory plan	AR tasks
Oct 15	9 – Membrane transport: Diffusion Jigsaw applied to Tuesday	• Observations, spontaneous, and semi-structured interviews, survey • Keep data collection journal after each section • Rewrite lab 10 according to jigsaw methods
Oct 22	10: Membrane transport: Osmosis Jigsaw applied to Wednesday	• Observations, spontaneous, and semi-structured interviews, survey • Keep data collection journal after each section • Rewrite lab 12 according to jigsaw methods
Oct 29	11: Mitosis	• Not a good week for data collection due to laboratory topic. • Evaluate changes in measurements – start with coding of qualitative sources - from one week to next. Reflect on data collection journal for any useful evidence. • Solve any issues.
Nov 5	12: Metabolism and Respiration Jigsaw method applied to Thursday	• Observations, spontaneous, and semi-structured interviews, survey • Keep data collection journal after each section
Nov 12		Focus groups with students to plan Action Plan – time offered before and after each of three sections.

Appendix C: Behavioral Checklist for Professorial Observations

Student (pseudonym)	Time	Engaged body language? Yes/no	On task? Yes/no	Subjective notes

Avoidance body language was judged by me to include not looking at group members, staring out the window, folding arms, leaning back or away from the table, playing with a cell phone instead of performing laboratory activities, or leaving the room.

Engaged body language was judged by me to include making eye contact with group members, turning toward group members as they speak, or leaning in to the table showing interest in the events at hand.

Appendix D: The Modified ASPECT survey

Based on Wiggins et al. 2017

Likert-type scale of 1 (strongly disagree) to 6 (Strongly agree)

1. Explaining the material to my group improved my understanding of it.
2. Having the material explained to me by my group members improved my understanding of the material.
3. Group discussion during today's activity contributed to my understanding of the course material.
4. I had fun during today's lab activity.
5. Overall, the other members of my group made valuable contributions during the lab activity.
6. I am confident in my understanding of the material presented during today's lab activity.
7. I made a valuable contribution to my group today.
8. I was focused during today's lab activity.
9. I worked hard during today's lab activity.